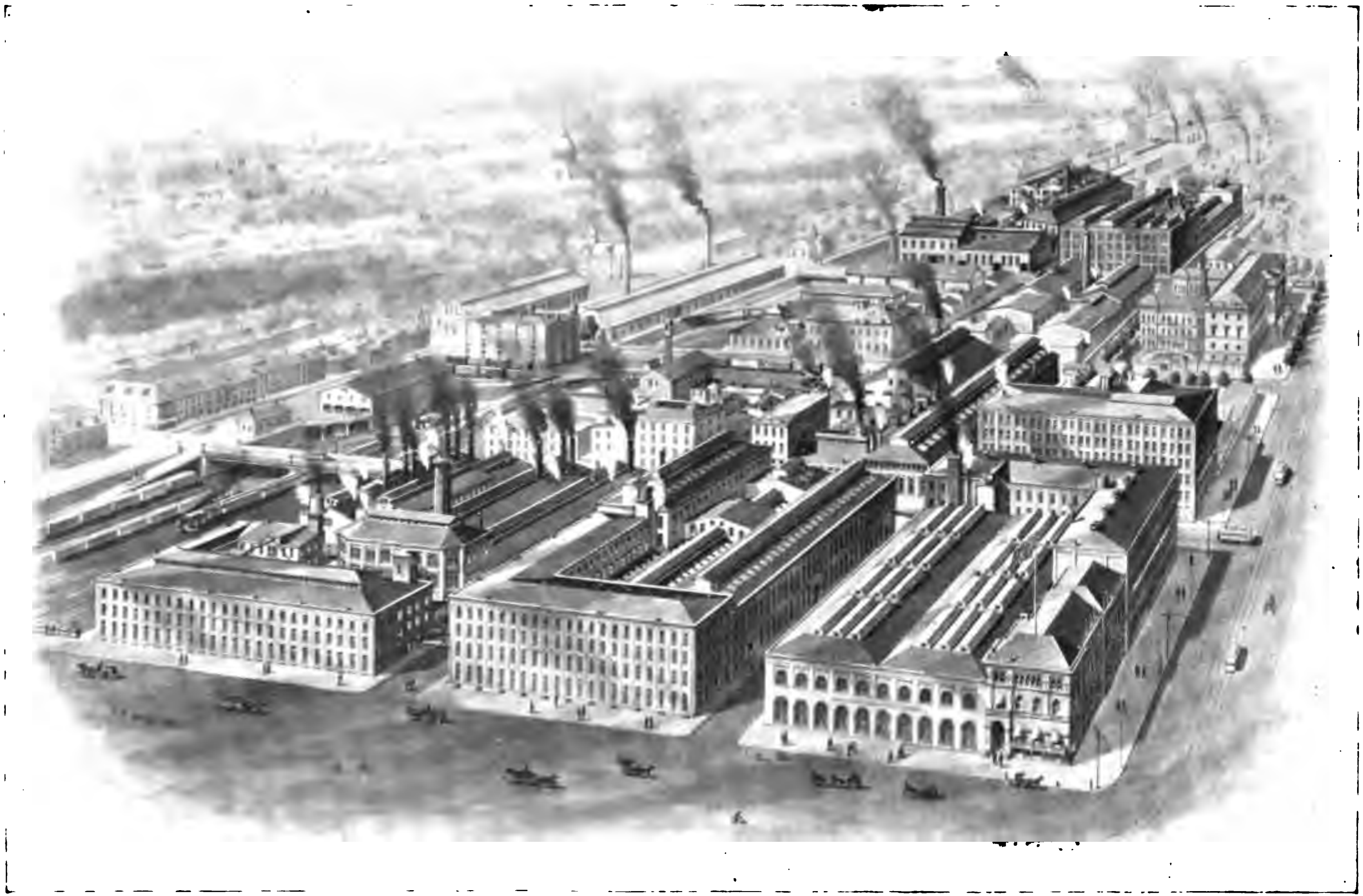

BALDWIN LOCOMOTIVE WORKS.

BALDWIN LOCOMOTIVE WORKS.

ILLUSTRATED CATALOGUE

OF

Narrow-Gauge Locomotives.

Adapted Especially to Gauges of 3 feet 6 inches
or one metre.

BURNHAM, WILLIAMS & CO.

PHILADELPHIA, PA., U. S. A.

(Cable Address: BALDWIN, PHILADELPHIA.)

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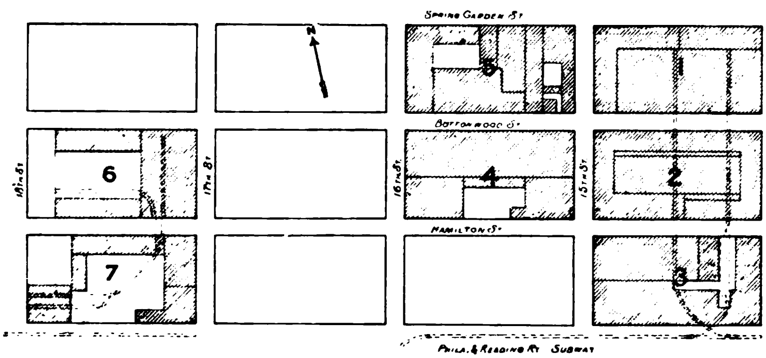
WILLIAM L. AUSTIN,
SAMUEL M. VAUCLAIN,
ALBA B. JOHNSON,
GEORGE BURNHAM, Jr.

PRESS OF
GEORGE H. BUCHANAN AND COMPANY.
1900

BALDWIN LOCOMOTIVE WORKS.

PLAN.

THE BALDWIN LOCOMOTIVE WORKS is situated with a front on Broad Street, Philadelphia, extending from Pennsylvania Avenue to Spring Garden Street. It also comprises two blocks bounded by Fifteenth and Sixteenth, Hamilton and Spring Garden Streets, and the greater part of two blocks between Seventeenth and Eighteenth, and from Buttonwood Street to Pennsylvania Avenue. The plan below shows the area occupied, over fourteen acres in all, of which about eleven acres are under roof.



1. Main Office, Drawing Room, Erecting Shop, Cylinder Shop, Paint Shop, and Store Room.

2. Boiler Shop, Machine Shop, Brass Machine Shop, Brass Foundry and Wheel Shop.

3. Machine Shop, Blacksmith Shop, Hammer Shop, and Power Plant.

4. Iron Foundry and Repair Shop.

5. Superintendent's Office, Laboratory, Pattern Shop, Electrical Department and Flange Shop.

6. Machine Shop, Tender Shop, and Sheet Iron Shop.

7. Spring Shop, Drop Hammer Shop, Hydraulic Smith Shop, Wood Shop, and Power Plant.

NOTE.—The shaded places indicate buildings occupied by the Baldwin Locomotive Works.

MATTHIAS W. BALDWIN.

HISTORY

OF THE

BALDWIN LOCOMOTIVE WORKS.

THE BALDWIN LOCOMOTIVE WORKS dates its origin from the inception of steam railroads in America. Called into existence by the early requirements of the railroad interests of the country, it has grown with their growth and kept pace with their progress. It has reflected in its career the successive stages of American railroad practice, and has itself contributed largely to the development of the locomotive as it exists to-day. A history of the Baldwin Locomotive Works, therefore, is, in a great measure, a record of the progress of locomotive engineering in this country, and as such cannot fail to be of interest to those who are concerned in this important element of our material progress.

MATTHIAS W. BALDWIN, the founder of the establishment, learned the trade of a jeweller, and entered the service of Fletcher & Gardiner, Jewellers and Silversmiths, Philadelphia, in 1817. Two years later he opened a small shop, in the same line of business, on his own account. The demand for articles of this character falling off, however, he formed a partnership, in 1825, with David Mason, a machinist, in the manufacture of bookbinders' tools and cylinders for calico-printing. Their shop was in a small alley which runs north from Walnut Street, above Fourth. They afterwards removed to Minor Street, below Sixth. The business was so successful that steam-power became necessary in carrying on their manufactures, and an engine was bought for the purpose. This proving unsatisfactory, Mr. Baldwin decided to design and construct one which should be specially

adapted to the requirements of his shop. One of these requirements was that it should occupy the least possible space, and this was met by the construction of an upright engine on a novel and ingenious plan. On a bed-plate about five feet square an upright cylinder was placed; the piston-rod connected to a cross-bar having two legs, turned downward, and sliding in grooves on the sides of the cylinder, which thus formed the guides. To the sides of these legs, at their lower ends, was connected by pivots an inverted U-shaped frame, prolonged at the arch into a single rod, which took hold of the crank of a fly-wheel carried by upright standards on the bed-plate. It will be seen that the length of the ordinary separate guide-bars was thus saved, and the whole engine was brought within the smallest possible compass. The design of the machine was not only unique, but its workmanship was so excellent, and its efficiency so great, as readily to procure for Mr. Baldwin orders for additional stationary engines. His attention was thus turned to steam engineering, and the way was prepared for his grappling with the problem of the locomotive when the time should arrive.

MR. BALDWIN'S FIRST ENGINE.

This original stationary engine, constructed prior to 1830, is still in good order and carefully preserved at the Works. It has successively supplied the power in six different departments as they have been opened, from time to time, in the growth of the business.

The manufacture of stationary steam engines thus took a prominent place in the establishment, and Mr. Mason shortly afterwards withdrew from the partnership.

In 1829-30 the use of steam as a motive power on railroads had begun to engage the attention of American engineers. A few locomotives had been imported from England, and one (which, however, was not successful) had been constructed at the West Point Foundry, in New York City. To gratify the

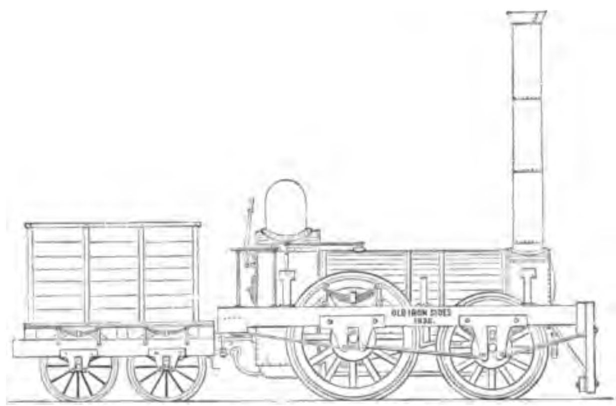
public interest in the new motor, Mr. Franklin Peale, then proprietor of the Philadelphia Museum, applied to Mr. Baldwin to construct a miniature locomotive for exhibition in his establishment. With the aid only of the imperfect published descriptions and sketches of the locomotives which had taken part in the Rainhill competition in England, Mr. Baldwin undertook the work, and on the 25th of April, 1831, the miniature locomotive was put in motion on a circular track made of pine boards covered with hoop iron, in the rooms of the Museum. Two small cars, containing seats for four passengers, were attached to it, and the novel spectacle attracted crowds of admiring spectators. Both anthracite and pine-knot coal were used as fuel, and the exhaust steam was discharged into the chimney, thus utilizing it to increase the draught.

The success of the model was such that, in the same year, Mr. Baldwin received an order for a locomotive from the Philadelphia, Germantown and Norristown Railroad Company, whose short line of six miles to Germantown was operated by horse-power. The Camden and Amboy Railroad Company had shortly before imported a locomotive from England, which was stored in a shed at Bordentown. It had not yet been put together; but Mr. Baldwin, in company with his friend, Mr. Peale, visited the spot, inspected the detached parts, and made a few memoranda of some of its principal dimensions. Guided by these figures and his experience with the Peale model, Mr. Baldwin commenced the task. The difficulties to be overcome in filling the order can hardly be appreciated at this day. There were few mechanics competent to do any part of the work on a locomotive. Suitable tools were with difficulty obtainable. Cylinders were bored by a chisel fixed in a block of wood and turned by hand. Blacksmiths able to weld a bar of iron exceeding one and one-quarter inches in thickness were few, or not to be had. It was necessary for Mr. Baldwin to do much of the work with his own hands, to educate the workmen who assisted him, and to improvise tools for the various processes.

The work was prosecuted, nevertheless, under all these difficulties, and the locomotive was fully completed, christened the "Old Ironsides," and tried on the road, November 23, 1832.

The circumstances of the trial are fully preserved, and are given, farther on, in the extracts from the journals of the day. Despite some imperfections, naturally occurring in a first effort, and which were afterwards to a great extent remedied, the engine was, for that early day, a marked and gratifying success. It was put at once into service, as appears from the company's advertisement three days after the trial, and did duty on the Germantown road and others for over a score of years.

The "Ironsides" was a four-wheeled engine, modelled essentially on the English practice of that day, as shown in the "Planet" class, and weighed, in running order, something over five tons. The rear or driving-wheels were fifty-four inches in



THE "OLD IRONSIDES," 1832.

diameter on a crank-axle placed in front of the fire-box. The cranks were thirty-nine inches from centre to centre. The front wheels, which were simply carrying wheels, were forty-five inches in diameter, on an axle placed just back of the cylinders. The cylinders were nine and one-half inches in diameter by eighteen inches stroke, and were attached horizontally to the outside of the smoke-box, which was D-shaped, with the sides receding inwardly, so as to bring the centre line of each cylinder in line with the centre of the crank. The wheels were made with heavy cast-iron hubs, wooden spokes and rims, and wrought-iron tires. The frame was of wood, placed outside the wheels. The boiler

was thirty inches in diameter, and contained seventy-two copper flues, one and one-half inches in diameter and seven feet long. The tender was a four-wheeled platform, with wooden sides and back, carrying an iron box for a water-tank, inclosed in a wooden casing, and with a space for fuel in front. The engine had no cab. The valve-motion was at first given by a single loose eccentric for each cylinder, placed on the axle between the crank and the hub of the wheel. On the inside of the eccentric was a half-circular slot, running half-way around. A stop was fastened to the axle at the arm of the crank, terminating in a pin which projected into the slot. The engine was reversed by changing the position of the eccentric on the axle by a lever operated from the footboard. This form of valve-motion was, however, shortly afterwards changed, and a single fixed eccentric for each cylinder substituted. The rock-shafts, which were under the footboard, had arms above and below, and the eccentric-straps had each a forked rod, with a hook, or an upper and lower latch or pin, at their extremities, to engage with the upper or lower arm of the rock-shaft. The eccentric-rods were raised or lowered by a double treadle, so as to connect with the upper or lower arm of the rock-shaft, according as forward or backward gear was desired. A peculiarity in the exhaust of the "Ironsides" was that there was only a single straight pipe running across from one cylinder to the other, with an opening in the upper side of the pipe, midway between the cylinders, to which was attached at right angles the perpendicular pipe into the chimney. The cylinders, therefore, exhausted against each other; and it was found, after the engine had been put in use, that this was a serious objection. This defect was afterwards remedied by turning each exhaust-pipe upward into the chimney, substantially as is now done. The steam-joints were made with canvas and red-lead, as was the practice in English locomotives, and in consequence much trouble was caused, from time to time, by leaking.

The price of the engine was to have been $4,000, but some difficulty was found in procuring a settlement. The company claimed that the engine did not perform according to contract; and objection was also made to some of the defects alluded to.

After these had been corrected as far as possible, however, Mr. Baldwin finally succeeded in effecting a compromise settlement, and received from the Company $3500 for the machine.

The results of the trial and the impression produced by it on the public mind may be gathered from the following extracts from the newspapers of the day:

The *United States Gazette* of November 24, 1832, remarks:

"A most gratifying experiment was made yesterday afternoon on the Philadelphia, Germantown and Norristown Railroad. The beautiful locomotive engine and tender, built by Mr. Baldwin, of this city, whose reputation as an ingenious machinist is well known, were for the first time placed on the road. The engine traveled about six miles, working with perfect accuracy and ease in all its parts, and with great velocity."

The *Chronicle* of the same date noticed the trial more at length, as follows:

"It gives us pleasure to state that the locomotive engine built by our townsman, M. W. Baldwin, has proved highly successful. In the presence of several gentlemen of science and information on such subjects, the engine was yesterday placed upon the road for the first time. All her parts had been previously highly finished and fitted together in Mr. Baldwin's factory. She was taken apart on Tuesday, and removed to the Company's depot, and yesterday morning she was completely together, ready for travel. After the regular passenger cars had arrived from Germantown in the afternoon, the tracks being clear, preparation was made for her starting. The placing fire in the furnace and raising steam occupied twenty minutes. The engine (with her tender) moved from the depot in beautiful style, working with great ease and uniformity. She proceeded about half a mile beyond the Union Tavern, at the township line, and returned immediately, a distance of six miles, at a speed of about twenty-eight miles to the hour, her speed having been slackened at all the road crossings, and it being after dark, but a portion of her power was used. It is needless to say that the spectators were delighted. From this experiment there is every reason to believe this engine will draw thirty tons gross, at an average speed of forty miles an hour, on a level road. The principal superiority of the engine over any of the English ones known consists in the light weight,—which is but between four and five tons,—her small bulk, and the simplicity of her working machinery. We rejoice at the result of this experiment, as it conclusively shows that Philadelphia, always famous for the skill of her mechanics, is enabled to produce steam-engines for railroads combining so many superior qualities as to warrant the belief that her mechanics will hereafter supply nearly all the public works of this description in the country."

On subsequent trials, the "Ironsides" attained a speed of thirty miles per hour, with its usual train attached. So great were the wonder and curiosity which attached to such a prodigy, that

people flocked to see the marvel, and eagerly bought the privilege of riding after the strange monster. The officers of the road were not slow to avail themselves of the public interest to increase their passenger receipts, and the following advertisement from *Poulson's American Daily Advertiser* of November 26, 1832, will show that as yet they regarded the new machine rather as a curiosity and a bait to allure travel than as a practical every-day servant:

PHILADELPHIA, GERMANTOWN, AND NORRISTOWN RAIL-ROAD.

LOCOMOTIVE ENGINE.

NOTICE.—The Locomotive Engine, (built by M. W. Baldwin, of this city,) will depart DAILY, when the weather is fair, with a TRAIN OF PASSENGER CARS, commencing on Monday the 26th inst., at the following hours, viz:—

FROM PHILADELPHIA.	FROM GERMANTOWN.
At 11 o'clock, A. M.	At 12 o'clock, M.
" 1 o'clock, P. M.	" 2 o'clock, P. M.
" 3 o'clock, P. M.	" 4 o'clock, P. M.

The Cars drawn by horses, will also depart as usual, from Philadelphia at 9 o'clock, A. M., and from Germantown at 10 o'clock, A. M., and at the above mentioned hours when the weather is not fair.

The points of starting, are from the Depot, at the corner of Green and Ninth street, Philadelphia; and from the Main street, near the centre of Germantown. Whole Cars can be taken. Tickets, 25 cents.

nov 24-3t

This announcement did not mean that in wet weather horses *would be attached to the locomotive* to aid it in drawing the train, but that the usual horse cars would be employed in making the trips upon the road without the engine.

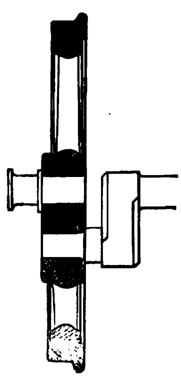
Upon making the first trip to Germantown with a passenger train with the "Ironsides," one of the drivers slipped upon the axle, causing the wheels to track less than the gauge of the road and drop in between the rails. It was also discovered that the valve arrangement of the pumps was defective, and they failed to supply the boiler with water. The shifting of the driving-wheel upon the axle fastened the eccentric, so that it would not operate in backward motion. These mishaps caused delay, and

prevented the engine from reaching its destination, to the great disappointment of all concerned. They were corrected in a few days, and the machine was used in experimenting upon its efficiency, making occasional trips with trains to Germantown. The road had an ascending grade, nearly uniform, of thirty-two feet per mile, and for the last half-mile of forty-five feet per mile, and it was found that the engine was too light for the business of the road upon these grades.

Such was Mr. Baldwin's first locomotive; and it is related of him that his discouragement at the difficulties which he had undergone in building it, and in finally procuring a settlement for it, was such that he remarked to one of his friends, with much decision, "That is our last locomotive."

It was some time before he received an order for another, but meanwhile the subject had become singularly fascinating to him, and occupied his mind so fully that he was eager to work out his new ideas in a tangible form.

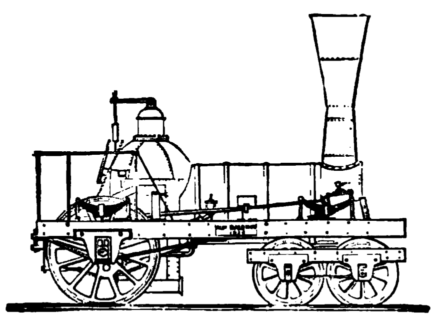
Shortly after the "Ironsides" had been placed on the Germantown road, Mr. E. L. Miller, of Charleston, S. C., came to Philadelphia and made a careful examination of the machine. Mr. Miller had, in 1830, contracted to furnish a locomotive to the Charleston and Hamburg Railroad Company, and accordingly the engine "Best Friend" had been built under his direction at the West Point Foundry, New York. After inspecting the "Ironsides," he suggested to Mr. Baldwin to visit the Mohawk and Hudson Railroad, and examine an English locomotive which had been placed on that road in July, 1831, by Messrs. Robert Stephenson & Co., of Newcastle, England. It was originally a four-wheeled engine of the "Planet" type, with horizontal cylinders and crank-axle. The front wheels of this engine were removed about a year after the machine was put at work, and a four-wheeled swiveling or "bogie" truck substituted. The result of Mr. Baldwin's investigations was the adoption of this design, but with some important improvements. Among these was the "half-crank," which he devised on his return from this



HALF-CRANK.

trip, and which he patented September 10, 1834. In this form of crank, the outer arm is omitted, and the wrist is fixed in a spoke of the wheel. In other words, the wheel itself formed one arm of the crank. The result sought and gained was that the cranks were strengthened, and, being at the extremities of the axle, the boiler could be made larger in diameter and placed lower. The driving-axle could also be placed back of the fire-box; the connecting-rods passing by the sides of the fire-box and taking hold inside of the wheels. This arrangement of the crank also involved the placing of the cylinders outside the smoke-box, as was done on the "Ironsides."

By the time the order for the second locomotive was received, Mr. Baldwin had matured this device and was prepared to embody it in practical form. The order came from Mr. E. L. Miller in behalf of the Charleston and Hamburg Railroad Company, and the engine bore his name, and was completed February 18, 1834. It was on six wheels; one pair being drivers, four and a half feet in diameter, with half-crank axle placed back of the fire-box as above described, and the four front wheels combined in a swivelling truck. The driving-wheels, it should be observed, were cast in solid bell-metal! The combined wood and iron wheels used on the "Ironsides" had proved objectionable, and Mr. Baldwin, in his endeavors to find a satisfactory substitute, had recourse to brass. June 29, 1833, he took out a patent for a cast-brass wheel, his idea being that by varying the hardness of the metal the adhesion of the drivers on the rails could be increased or diminished at will. The brass wheels on the "Miller," however, soon wore out, and the experiment with this metal was not repeated. The "E. L. Miller" had cylinders ten inches in diameter; stroke of piston, sixteen inches; and weighed, with water in the boiler, seven tons eight hundred-



BALDWIN ENGINE, 1834.

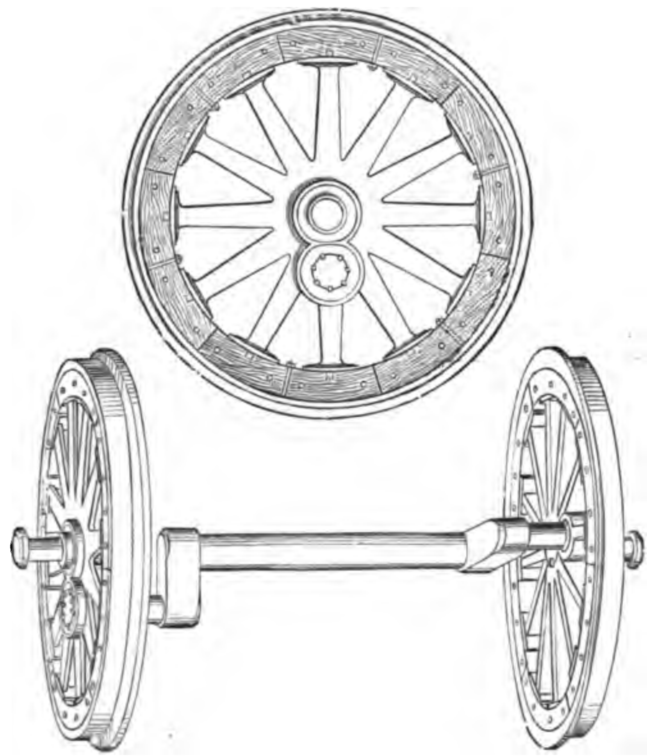
weight. The boiler had a high dome over the fire-box; and this form of construction, it may be noted, was followed, with a few exceptions, for many years.

The valve-motion was given by a single fixed eccentric for each cylinder. Each eccentric-strap had two arms attached to it, one above and the other below, and, as the driving-axle was back of the fire-box, these arms were prolonged backward under the footboard, with a hook on the inner side of the end of each. The rock-shaft had arms above and below its axis, and the hooks of the two rods of each eccentric were moved by hand-levers so as to engage with either arm, thus producing backward or forward gear. This form of single eccentric, peculiar to Mr. Baldwin, was in the interest of simplicity in the working parts, and was adhered to for some years. It gave rise to an animated controversy among mechanics as to whether, with its use, it was possible to get a lead on the valve in both directions. Many maintained that this was impracticable; but Mr. Baldwin demonstrated by actual experience that the reverse was the case.

Meanwhile, the Commonwealth of Pennsylvania had given Mr. Baldwin an order for a locomotive for the State Road, as it was then called, from Philadelphia to Columbia, which, up to that time, had been worked by horses. This engine, called the "Lancaster," was completed in June, 1834. It was similar to the "Miller," and weighed seventeen thousand pounds. After it was placed in service, the records show that it hauled at one time nineteen loaded burden cars over the highest grades between Philadelphia and Columbia. This was characterized at the time by the officers of the road as an "unprecedented performance." The success of the machine on its trial trips was such that the Legislature decided to adopt steam-power for working the road, and Mr. Baldwin received orders for several additional locomotives. Two others were accordingly delivered to the State in September and November respectively of that year, and one was also built and delivered to the Philadelphia and Trenton Railroad Company during the same season. This latter engine, which was put in service October 21, 1834, averaged twenty-one thousand miles per year to September 15, 1840.

Five locomotives were thus completed in 1834, and the new

business was fairly under way. The building in Lodge Alley, to which Mr. Baldwin had removed from Minor Street, and where these engines were constructed, began to be found too contracted, and another removal was decided upon. A location on Broad and Hamilton Streets (the site, in part, of the present works) was selected, and a three-story L-shaped brick building, fronting



BALDWIN COMPOUND WOOD AND IRON WHEELS, 1834.

on both streets, erected. This was completed and the business removed to it during the following year (1835). The original building was partially destroyed by fire in 1884, and was replaced by a four-story brick structure.

These early locomotives, built in 1834, were the types of Mr. Baldwin's practice for some years. All, or nearly all of them,

embraced several important devices, which were the results of his study and experiments up to that time. The devices referred to were patented September 10, 1834, and the same patent covered the following four inventions, viz.:

1. The half-crank, and method of attaching it to the driving-wheel. (This has already been described.)

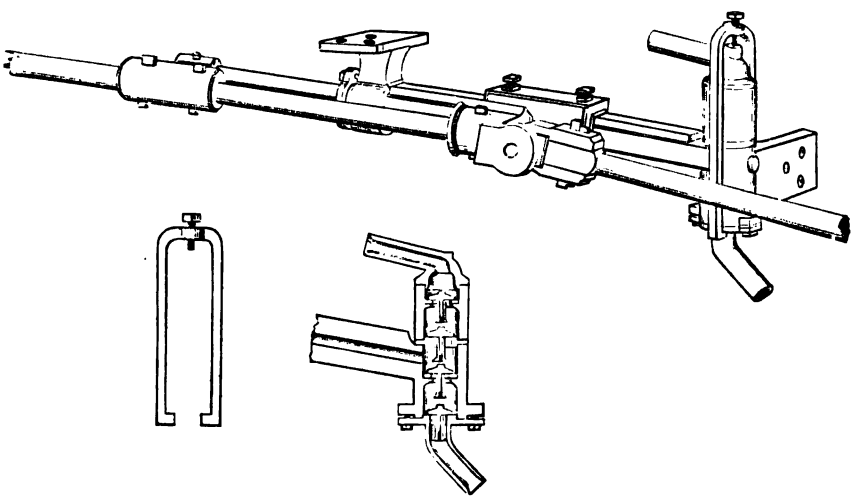
2. A new mode of constructing the wheels of locomotive engines and cars. In this the hub and spokes were of cast iron, cast together. The spokes were cast without a rim, and terminated in segment flanges, each spoke having a separate flange disconnected from its neighbors. By this means, it was claimed, the injurious effect of the unequal expansion of the materials composing the wheels was lessened or altogether prevented. The flanges bore against wooden felloes, made in two thicknesses, and put together so as to break joints. Tenons or pins projected from the flanges into openings made in the wooden felloes, to keep them in place. Around the whole the tire was passed and secured by bolts. The sketch on page 17 shows the device.

3. A new mode of forming the joints of steam and other tubes. This was Mr. Baldwin's invention of ground joints for steam-pipes, which was a very valuable improvement over previous methods of making joints with red-lead packing, and which rendered it possible to carry a much higher pressure of steam.

4. A new mode of forming the joints and other parts of the supply-pump, and of locating the pump itself. This invention consisted in making the single guide-bar hollow and using it for the pump-barrel. The pump-plunger was attached to the piston-rod at a socket or sleeve formed for the purpose, and the hollow guide-bar terminated in the vertical pump-chamber. This chamber was made in two pieces, joined about midway between the induction and eduction pipes. This joint was ground steam-tight, as were also the joints of the induction-pipe with the bottom of the lower chamber, and the flange of the eduction-pipe with the top of the upper chamber. All these parts were held together by a stirrup with a set-screw in its arched top, and the arrangement was such that by simply unscrewing this set-screw the

different sections of the chamber, with all the valves, could be taken apart for cleaning or adjusting. The cut below illustrates the device.

It is probable that the five engines built during 1834 embodied all, or nearly all, these devices. They all had the half-crank, the ground joints for steam-pipes (which were first made by him in 1833), and the pump formed in the guide-bar, and all had the four-wheeled truck in front, and a single pair of drivers back of the fire-box. On this position of the driving-wheels Mr. Baldwin laid great stress, as it made a more even distribution of the



PUMP AND STIRRUP

weight, throwing about one-half on the drivers and one-half on the four-wheeled truck. It also extended the wheel-base, making the engine much steadier and less damaging to the track. Mr. William Norris, who had established a locomotive works in Philadelphia in 1832, was at this time building a six-wheeled engine with a truck in front and the driving-wheels placed in front of the fire-box. Considerable rivalry naturally existed between the two manufacturers as to the comparative merits of their respective plans. In Mr. Norris's engine, the position of the driving-axle in front of the fire-box threw on it more of the

weight of the engine, and thus increased the adhesion and the tractive power. Mr. Baldwin, however, maintained the superiority of his plan, as giving a better distribution of the weight and a longer wheel-base, and consequently rendering the machine less destructive to the track. As the iron rails then in use were generally light, and much of the track was of wood, this feature was of some importance.

To the use of the ground joint for steam-pipes, however, much of the success of his early engines was due. The English builders were making locomotives with canvas and red-lead joints, permitting a steam pressure of only sixty pounds per inch to be carried, while Mr. Baldwin's machines were worked at one hundred and twenty pounds with ease. Several locomotives imported from England at about this period by the Commonwealth of Pennsylvania for the State Road (three of which were made by Stephenson) had canvas and red-lead joints, and their efficiency was so much less than that of the Baldwin engines, on account of this and other features of construction, that they were soon laid aside or sold.

In June, 1834, a patent was issued to Mr. E. L. Miller, by whom Mr. Baldwin's second engine was ordered, for a method of increasing the adhesion of a locomotive by throwing a part of the weight of the tender on the rear of the engine, thus increasing the weight on the drivers. Mr. Baldwin adopted this device on an engine built for the Philadelphia and Trenton Railroad Company, May, 1835, and thereafter used it largely, paying one hundred dollars royalty for each engine. Eventually (May 6, 1839,) he bought the patent for nine thousand dollars, evidently considering that the device was especially valuable, if not indispensable, in order to render his engine as powerful, when required, as other patterns having the driving-wheels in front of the fire-box, and therefore utilizing more of the weight of the engine for adhesion.

In making the truck and tender-wheels of these early locomotives, the hubs were cast in three pieces and afterwards banded with wrought-iron, the interstices being filled with spelter. This method of construction was adopted on account of the difficulty then found in casting a chilled wheel in one solid piece.

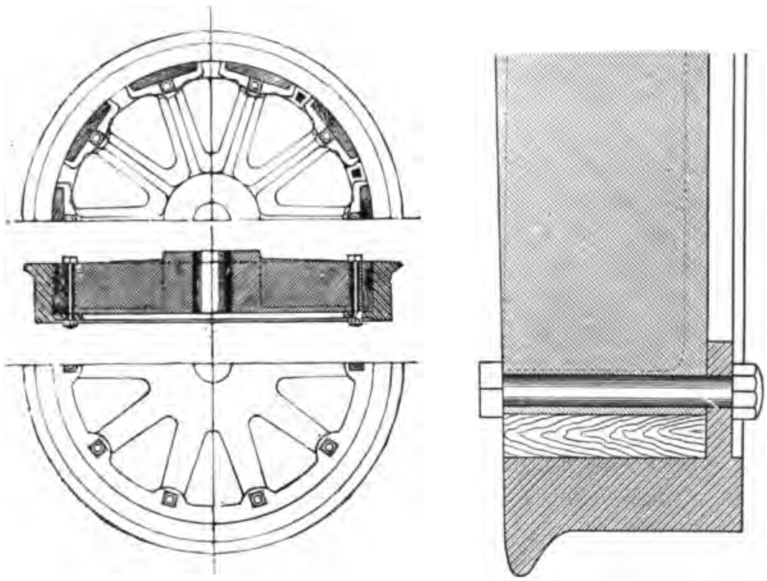
Early in 1835, the new shop on Broad Street was completed and occupied. Mr. Baldwin's attention was thenceforward given to locomotive building exclusively, except that a stationary engine was occasionally constructed.

In May, 1835, his eleventh locomotive, the "Black Hawk," was delivered to the Philadelphia and Trenton Railroad Company. This was the first outside-connected engine of his build. It was also the first engine on which the Miller device of attaching part of the weight of the tender to the engine was employed. On the eighteenth engine, the "Brandywine," built for the Philadelphia and Columbia Railroad Company, brass tires were used on the driving-wheels, for the purpose of obtaining more adhesion; but they wore out rapidly and were replaced with iron.

April 3, 1835, Mr. Baldwin took out a patent for certain improvements in the wheels and tubes of locomotive engines. That relating to the wheels provided for casting the hub and spokes together, and having the spokes terminate in segments of a rim, as described in his patent of September 10, 1834. Between the ends of the spokes and the tires, wood was interposed, and the tire might be either of wrought-iron or of chilled cast-iron. The intention was expressed of making the tire usually of cast-iron chilled. The main object, however, was declared to be the interposition between the spokes and the rim of a layer of wood or other substance possessing some degree of elasticity. This method of making driving-wheels was followed for several years, the tires being made with a shoulder. See illustration on page 22.

The improvement in locomotive tubes consisted in driving a copper ferrule or thimble on the outside of the end of the tube, and soldering it in place, instead of driving a ferrule into the tube, as had previously been the practice. The object of the latter method had been to make a tight joint with the tube-sheet; but by putting the ferrule on the outside of the tube, not only was the joint made as tight as before, but the tube was strengthened, and left unobstructed throughout to the full extent of its diameter. This method of setting flues has been generally followed in the works from that date to the present, the only difference being that, at this time, with iron tubes, the end is

swedged down, the copper ferrule brazed on, and the iron end turned or riveted over against the copper thimble and the flue-sheet, to make the joint perfect.



DRIVING WHEELS, PATENTED SEPTEMBER, 1834.

Fourteen engines were constructed in 1835; forty in 1836; forty in 1837; twenty-three in 1838; twenty-six in 1839; and nine in 1840. During all these years the general design continued the same; but, in compliance with the demand for more power, three sizes were furnished, as follows:

First class.	Cylinders,	12½×16;	weight,	loaded,	26,000	pounds.
Second class.	"	12 ×16;	"	"	24,000	"
Third class.	"	10½×16;	"	"	20,000	"

The first-class engine he fully believed, in 1838, was as heavy as would be called for, and he declared that it was as large as he intended to make. Most of the engines were built with the half-crank, but occasionally an outside-connected machine was turned out. These latter, however, failed to give as complete satisfaction as the half-crank machine. The drivers were generally four and a half feet in diameter.

A patent was issued to Mr. Baldwin, August 17, 1835, for his device of cylindrical pedestals. In this method of construction, the pedestal was of cast-iron, and was bored in a lathe so as to form two concave jaws. The boxes were also turned in a lathe so that their vertical ends were cylindrical, and they were thus fitted in the pedestals. This method of fitting up pedestals and boxes was cheap and effective, and was used for some years for the driving and tender wheels.

As showing the estimation in which these early engines were held, it may not be out of place to refer to the opinions of some of the railroad managers of that period.

Mr. L. A. Sykes, engineer of the New Jersey Transportation Company, under date of June 12, 1838, wrote that he could draw with his engines twenty four-wheeled cars with twenty-six passengers each, at a speed of twenty to twenty-five miles per hour, over grades of twenty-six feet per mile. "As to simplicity of construction," he adds, "small liability to get out of order, economy of repairs, and ease to the road, I fully believe Mr. Baldwin's engines stand unrivalled. I consider the simplicity of the engine, the arrangement of the working parts, and the distribution of the weight, far superior to any engine I have ever seen, either of American or English manufacture, and I have not the least hesitation in saying, that Mr. Baldwin's engine will do the same amount of work with much less repairs, either to the engine or the track, than any other engine in use."

L. G. Cannon, President of the Rensselaer and Saratoga Railroad Company, writes: "Your engines will, in performance and cost of repairs, bear comparison with any other engine made in this or any other country."

Some of Mr. Baldwin's engines on the State Road, in 1837, cost, for repairs, only from one and two-tenths to one and six-tenths cents per mile. It is noted that the engine "West Chester," on the same road, weighing twenty thousand seven hundred and thirty-five pounds (ten thousand four hundred and seventy-five on drivers), drew fifty-one cars (four-wheeled), weighing two hundred and eighty-nine net tons, over the road, some of the track being of wood covered with strap-rail.

The financial difficulties of 1836 and 1837, which brought

ruin upon so many, did not leave Mr. Baldwin unscathed. His embarrassments became so great that he was unable to proceed, and was forced to call his creditors together for a settlement. After offering to surrender all his property, his shop, tools, house, and everything, if they so desired,—all of which would realize only about twenty-five per cent. of their claims,—he proposed to them that they should permit him to go on with the business, and in three years he would pay the full amount of all claims, principal and interest. This was finally acceded to, and the promise was in effect fulfilled, although not without an extension of two years beyond the time originally proposed.

In May, 1837, the number of hands employed was three hundred, but this number was reducing weekly, owing to the falling off in the demand for engines.

These financial troubles had their effect on the demand for locomotives, as will be seen in the decrease in the number built in 1838, 1839, and 1840; and this result was furthered by the establishment of several other locomotive works, and the introduction of other patterns of engines.

The changes and improvements in details made during these years may be summed up as follows:

The subject of burning anthracite coal had engaged much attention. In October, 1836, Mr. Baldwin secured a patent for a grate or fireplace which could be detached from the engine at pleasure, and a new one with a fresh coal fire substituted. The intention was to have the grate with freshly ignited coal all ready for the engine on its arival at a station, and placed between the rails over suitable levers, by which it could be attached quickly to the fire-box. It is needless to say that this was never practised. In January, 1838, however, Mr. Baldwin was experimenting with the consumption of coal on the Germantown road, and in July of the same year the records show that he was making a locomotive to burn coal, part of the arrangement being to blow the fire with a fan.

Up to 1838, Mr. Baldwin had made both driving and truck wheels with wrought tires, but during that year chilled wheels for engine and tender trucks were adopted, His tires were furnished by Messrs. S. Vail & Son, Morristown, N. J., who

made the only tires then obtainable in America. They were very thin, being only one inch to one and a half inches thick; and Mr. Baldwin, in importing some tires from England at that time, insisted on their being made double the ordinary thickness. The manufacturers at first objected and ridiculed the idea, the practice being to use two tires when extra thickness was wanted, but finally they consented to meet his requirements.

All his engines thus far had the single eccentric for each valve, but at about this period double eccentrics were adopted, each terminating in a straight hook, and reversed by hand-levers.

At this early period, Mr. Baldwin had begun to feel the necessity of making all like parts of locomotives of the same class in such manner as to be absolutely interchangeable. Steps were taken in this direction, but it was not until many years afterwards that the system of standard gauges was perfected, which has since grown to be a distinguishing feature in the establishment.

In March, 1839, Mr. Baldwin's records show that he was building a number of outside-connected engines, and had succeeded in making them strong and durable. He was also making a new chilled wheel, and one which he thought would not break.

On the one hundred and thirty-sixth locomotive, completed October 18, 1839, for the Philadelphia, Germantown and Norristown Railroad, the old pattern of wooden frame was abandoned, and no outside frame whatever was employed,—the machinery, as well as the truck and the pedestals of the driving-axles, being attached directly to the naked boiler. The wooden frame thenceforward disappeared gradually, and an iron frame took its place. Another innovation was the adoption of eight-wheeled tenders, the first of which was built at about this period.

April 8, 1839, Mr. Baldwin associated with himself Messrs. Vail & Hufty, and the business was conducted under the firm name of Baldwin, Vail & Hufty until 1841, when Mr. Hufty withdrew, and Baldwin & Vail continued the copartnership until 1842.

The time had now arrived when the increase of business on railroads demanded more powerful locomotives. It had for some years been felt that for freight traffic the engine with one pair of

drivers was insufficient. Mr. Baldwin's engine had the single pair of drivers placed back of the fire-box; that made by Mr. Norris, one pair in front of the fire-box. An engine with two pairs of drivers, one pair in front and one pair behind the fire-box, was the next logical step, and Mr. Henry R. Campbell, of Philadelphia, was the first to carry this design into execution. Mr. Campbell, as has been noted, was the Chief Engineer of the Germantown Railroad when the "Ironsides" was placed on that line, and had since given much attention to the subject of locomotive construction. February 5, 1836, Mr. Campbell secured a patent for an eight-wheeled engine with four drivers connected, and a four-wheeled truck in front; and subsequently contracted with James Brooks, of Philadelphia, to build for him such a machine. The work was begun March 16, 1836, and the engine was completed May 8, 1837. This was the first eight-wheeled engine of this type, and from it the standard American locomotive of to-day takes its origin. The engine lacked, however, one essential feature; there were no equalizing beams between the drivers, and nothing but the ordinary steel springs over each journal of the driving axles to equalize the weight upon them. It remained for Messrs. Eastwick & Harrison to supply this deficiency; and in 1837 that firm constructed at their shop in Philadelphia, a locomotive on this plan, but with the driving-axles running in a separate square frame, connected to the main frame above it by a single central bearing on each side. This engine had cylinders twelve by eighteen, four coupled driving-wheels, forty-four inches in diameter, carrying eight of the twelve tons constituting the total weight. Subsequently, Mr. Joseph Harrison, Jr., of the same firm, substituted "equalizing beams" on engines of this plan afterwards constructed by them, substantially in the same manner as since generally employed.

In the *American Railroad Journal* of July 30, 1836, a wood-cut showing Mr. Campbell's engine, together with an elaborate calculation of the effective power of an engine on this plan, by William J. Lewis, Esq., Civil Engineer, was published, with a table showing its performance upon grades ranging from a dead level to a rise of one hundred feet per mile. Mr. Campbell stated that his experience at that time (1835-36) convinced him

that grades of one hundred feet rise per mile would, if roads were judiciously located, carry railroads over any of the mountain passes in America, without the use of planes with stationary steam power, or, as a general rule, of costly tunnels,—an opinion very extensively verified by the experience of the country since that date.

A step had thus been taken towards a plan of locomotive having more adhesive power. Mr. Baldwin, however, was slow to adopt the new design. He naturally regarded innovations with distrust. He had done much to perfect the old pattern of engine, and had built over a hundred of them, which were in successful operation on various railroads. Many of the details were the subjects of his several patents, and had been greatly simplified in his practice. In fact, simplicity in all the working parts had been so largely his aim, that it was natural that he should distrust any plan involving additional machinery, and he regarded the new design as only an experiment at best. In November, 1838, he wrote to a correspondent that he did not think there was any advantage in the eight-wheeled engine. There being three points in contact, it could not turn a curve, he argued, without slipping one or the other pair of wheels sideways. Another objection was in the multiplicity of machinery and the difficulty in maintaining four driving-wheels all of exactly the same size. Some means, however, of getting more adhesion must be had, and the result of his reflections upon this subject was the project of a "geared engine." In August, 1839, he took steps to secure a patent for such a machine, and December 31, 1840, letters patent were granted him for the device. In this engine, an independent shaft or axle was placed between the two axles of the truck, and connected by cranks and coupling-rods with cranks on the outside of the driving-wheels. This shaft had a central cog-wheel engaging on each side with intermediate cog-wheels, which in turn geared into cog-wheels on each truck-axle. The intermediate cog-wheels had wide teeth, so that the truck could pivot while the main shaft remained parallel with the driving-axle. The diameters of the cog-wheels were, of course, in such proportion to the driving- and truck-wheels that the latter should revolve as much oftener

than the drivers as their smaller size might require. Of the success of this machine for freight service, Mr. Baldwin was very sanguine. One was put in hand at once, completed in August, 1841, and eventually sold to the Sugarloaf Coal Company. It was an outside-connected engine, weighing thirty thousand pounds, of which eleven thousand seven hundred and seventy-five pounds were on the drivers, and eighteen thousand three hundred and thirty-five on the truck. The driving-wheels were forty-four and the truck-wheels thirty-three inches in diameter. The cylinders were thirteen inches in diameter by sixteen inches stroke. On a trial of the engine upon the Philadelphia and Reading Railroad, it hauled five hundred and ninety tons from Reading to Philadelphia—a distance of fifty-four miles—in five hours and twenty-two minutes. The Superintendent of the road, in writing of the trial, remarked that this train was unprecedented in length and weight both in America and Europe. The performance was noticed in favorable terms by the Philadelphia newspapers, and was made the subject of a report by the Committee on Science and Arts of the Franklin Institute, who strongly recommended this plan of engine for freight service. The success of the trial led Mr. Baldwin at first to believe that the geared engine would be generally adopted for freight traffic; but in this he was disappointed. No further demand was made for such machines, and no more of them were built.

In 1840, Mr. Baldwin received an order, through August Belmont, Esq., of New York, for a locomotive for Austria, and had nearly completed one which was calculated to do the work required, when he learned that only sixty pounds pressure of steam was admissible, whereas his engine was designed to use steam at one hundred pounds and over. He accordingly constructed another, meeting this requirement, and shipped it in the following year. This engine, it may be noted, had a kind of link-motion, agreeably to the specification received, and was the first of his make upon which the link was introduced.

Mr. Baldwin's patent of December 31, 1840, already referred to as covering his geared engine, embraced several other devices, as follows:

1. A method of operating a fan, or blowing-wheel, for the

purpose of blowing the fire. The fan was to be placed under the footboard, and driven by the friction of a grooved pulley in contact with the flange of the driving-wheel.

2. The substitution of a metallic stuffing, consisting of wire, for the hemp, wool, or other material which had been employed in stuffing-boxes.

3. The placing of the springs of the engine truck so as to obviate the evil of the locking of the wheels when the truck-frame vibrates from the centre-pin vertically. Spiral as well as semi-elliptic springs, placed at each end of the truck-frame, were specified. The spiral spring is described as received in two cups, —one above and one below. The cups were connected together at their centres, by a pin upon one and a socket in the other, so that the cups could approach towards or recede from each other and still preserve their parallelism.

4. An improvement in the manner of constructing the iron frames of locomotives, by making the pedestals in one piece with and constituting part of, the frames.

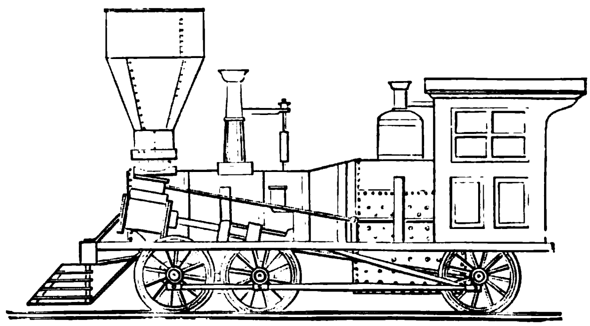
5. The employment of spiral springs in connection with cylindrical pedestals and boxes. A single spiral was at first used, but, not proving sufficiently strong, a combination or nest of spirals curving alternately in opposite directions was afterwards employed. Each spiral had its bearing in a spiral recess in the pedestal.

In the specification of this patent a change in the method of making cylindrical pedestals and boxes is noted. Instead of boring and turning them in a lathe, they were cast to the required shape in chills. This method of construction was used for a time, but eventually a return was made to the original plan, as giving a more accurate job.

In 1842, Mr. Baldwin constructed, under an arrangement with Mr. Ross Winans, three locomotives for the Western Railroad of Massachusetts, on a plan which had been designed by that gentleman for freight traffic. These machines had upright boilers, and horizontal cylinders which worked cranks on a shaft bearing cog-wheels engaging with other cog-wheels on an intermediate shaft. This latter shaft had cranks coupled to four driving-wheels on each side. These engines were constructed

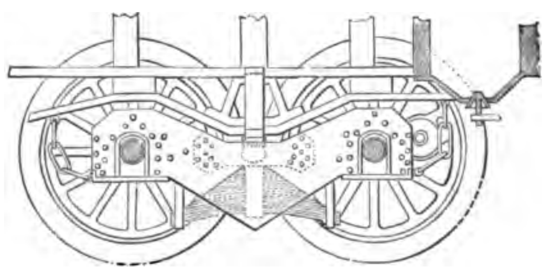
to burn anthracite coal. Their peculiarly uncouth appearance earned for them the name of "crabs," and they were but short lived in service.

But to return to the progress of Mr. Baldwin's locomotive practice. The geared engine had not proved a success. It was unsatisfactory, as well to its designer as to the railroad com-



BALDWIN SIX-WHEELS-CONNECTED ENGINE, 1842.

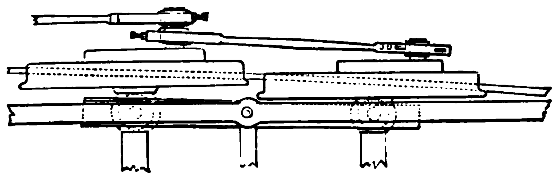
munity. The problem of utilizing more or all of the weight of the engine for adhesion remained, in Mr. Baldwin's view, yet to be solved. The plan of coupling four or six wheels had long



BALDWIN FLEXIBLE-BEAM TRUCK, 1842.—ELEVATION.

before been adopted in England, but on the short curves prevalent on American railroads he felt that something more was necessary. The wheels must not only be coupled, but at the same time must be free to adapt themselves to a curve. These two conditions were apparently incompatible, and to reconcile these inconsistencies was the task which Mr. Baldwin set himself to accomplish. He undertook it, too, at a time when his business had

fallen off greatly and he was involved in the most serious financial embarrassments. The problem was constantly before him, and at length, during a sleepless night, its solution flashed across his mind. The plan so long sought for, and which, subsequently,



HALF PLAN.

more than any other of his improvements or inventions, contributed to the foundation of his fortune, was his well-known six-wheels-connected locomotive with the four front drivers combined in a flexible truck. For this machine Mr. Baldwin secured a patent, August 25, 1842. Its principal characteristic features are now matters of history, but they deserve here a brief mention. The engine was on six wheels, all connected as drivers. The rear wheels were placed rigidly in the frames, usually behind the fire-box, with inside bearings. The cylinders were inclined, and with outside connections. The four remaining wheels had inside journals running in boxes held by two wide and deep wrought-iron beams, one on each side. These beams were unconnected, and entirely independent of each other. The pedestals formed in them were bored out cylindrically, and into them cylindrical boxes, as patented by him in 1835, were fitted. The engine frame on each side was directly over the beam, and a spherical pin, running down from the frame, bore in a socket in the beam midway between the two axles. It will thus be seen that each side-beam independently could turn horizontally or vertically under the spherical pin, and the cylindrical boxes could also turn in the pedestals. Hence, in passing a curve, the middle pair of drivers could move laterally in one direction—say to the right—while the front pair could move in the opposite direction, or to the left; the two axles all the while remaining parallel to each other and to the rear driving-axle. The operation of these beams was, therefore, like that of the parallel-ruler. On a straight line the

two beams and the two axles formed a rectangle; on curves, a parallelogram, the angles varying with the degree of curvature. The coupling-rods were made with cylindrical brasses, thus forming ball-and-socket joints, to enable them to accommodate themselves to the lateral movements of the wheels. Colburn, in his "Locomotive Engineering," remarks of this arrangement of rods as follows:

"Geometrically, no doubt, this combination of wheels could only work properly around curves by a lengthening and shortening of the rods which served to couple the principal pair of driving-wheels with the hind truck-wheels. But if the coupling-rods from the principal pair of driving-wheels be five feet long, and if the beams of the truck-frame be four feet long (the radius of curve described by the axle-boxes around the spherical side bearings being two feet), then the total corresponding lengthening of the coupling-rods, in order to allow the hind truck-wheels to move one inch to one side, and the front wheels of the truck one inch to the other side of their normal position on a straight line, would be $\sqrt{60^2+1^2}-60+24-\sqrt{24^2-1^2}=0.0275$ inch, or less than one thirty-second of an inch. And if only one pair of driving-wheels were thus coupled with a four-wheeled truck, the total wheel-base being nine feet, the motion permitted by this slight elongation of the coupling-rods (an elongation provided for by a trifling slackness in the brasses) would enable three pairs of wheels to stand without binding in a curve of only one hundred feet radius."

The first engine of the new plan was finished early in December, 1842, being one of fourteen engines constructed in that year, and was sent to the Georgia Railroad, on the order of Mr. J. Edgar Thomson, then Chief Engineer and Superintendent of that line. It weighed twelve tons, and drew, besides its own weight, two hundred and fifty tons up a grade of thirty-six feet to the mile.

Other orders soon followed. The new machine was received generally with great favor. The loads hauled by it exceeded anything so far known in American railroad practice, and sagacious managers hailed it as a means of largely reducing operating expenses. On the Central Railroad of Georgia, one of these twelve-ton engines drew nineteen eight-wheeled cars, with seven hundred and fifty bales of cotton, each bale weighing four hundred and fifty pounds, over maximum grades of thirty feet per mile, and the manager of the road declared that it could readily take one thousand bales. On the Philadelphia and Reading Railroad a similar engine of eighteen tons weight drew one hundred

and fifty loaded cars (total weight of cars and lading, one thousand one hundred and thirty tons) from Schuylkill Haven to Philadelphia, at a speed of seven miles per hour. The regular load was one hundred loaded cars, which were hauled at a speed of from twelve to fifteen miles per hour on a level.

The following extract from a letter, dated August 10, 1844, of Mr. G. A. Nicolls, then superintendent of that line, gives the particulars of the performance of these machines, and shows the estimation in which they were held:

> "We have had two of these engines in operation for about four weeks. Each engine weighs about forty thousand pounds with water and fuel, equally distributed on six wheels, all of which are coupled, thus gaining the whole adhesion of the engine's weight. Their cylinders are fifteen by eighteen inches.
>
> "The daily allotted load of each of these engines is one hundred coal cars, each loaded with three and six-tenths tons of coal, and weighing two and fifteen one-hundredths tons each, empty; making a net weight of three hundred and sixty tons of coal carried, and a gross weight of train of five hundred and seventy-five tons, all of two thousand two hundred and forty pounds.
>
> "This train is hauled over the ninety-four miles of the road, half of which is level, at the rate of twelve miles per hour; and with it the engine is able to make fourteen to fifteen miles per hour on a level.
>
> "Were all the cars on the road of sufficient strength, and making the trip by daylight, nearly one-half being now performed at night, I have no doubt of these engines being quite equal to a load of eight hundred tons gross, as their average daily performance on any of the levels of our road, some of which are eight miles long.
>
> "In strength of make, quality of workmanship, finish, and proportion of parts, I consider them equal to any, and superior to most, freight engines I have seen. They are remarkably easy on the rail, either in their vertical or horizontal action, from the equalization of their weight, and the improved truck under the forward part of the engine. This latter adapts itself to all the curves of the road, including some of seven hundred and sixteen feet radius in the main track, and moves with great ease around our turning Y curves at Richmond, of about three hundred feet radius.
>
> "I consider these engines as near perfection, in the arrangement of their parts, and their general efficiency, as the present improvements in machinery and the locomotive engine will admit of. They are saving us thirty per cent. in every trip on the former cost of motive or engine power."

But the flexible-beam truck also enabled Mr. Baldwin to meet the demand for an engine with four drivers connected. Other builders were making engines with four drivers and a four-wheeled truck, of the present American standard type. To compete with this design, Mr. Baldwin modified his six-wheels-

connected engine by connecting only two out of the three pairs of wheels as drivers, making the forward wheels of smaller diameter as leading wheels, but combining them with the front drivers in a flexible-beam truck. The first engine on this plan was sent to the Erie and Kalamazoo Railroad, in October, 1843, and gave great satisfaction. The superintendent of the road was enthusiastic in its praise, and wrote to Mr. Baldwin that he doubted "if anything could be got up which would answer the business of the road so well." One was also sent to the Utica and Schenectady Railroad a few weeks later, of which the superintendent remarked that "it worked beautifully, and there were not wagons enough to give it a full load." In this plan the leading wheels were usually made thirty-six and the drivers fifty-four inches in diameter.

This machine, of course, came in competition with the eight-wheeled engine having four drivers, and Mr. Baldwin claimed for his plan a decided superiority. In each case about two-thirds of the total weight was carried on the four drivers, and Mr. Baldwin maintained that his engine, having only six instead of eight wheels, was simpler and more effective.

At about this period Mr. Baldwin's attention was called by Mr. Levi Bissell to an "Air-Spring" which the latter had devised, and which it was imagined was destined to be a cheap, effective, and perpetual spring. The device consisted of a small cylinder placed above the frame over the axle-box, and having a piston fitted air-tight into it. The piston-rod was to bear on the axle-box and the proper quantity of air was to be pumped into the cylinder above the piston, and the cylinder then hermetically closed. The piston had a leather packing which was to be kept moist by some fluid (molasses was proposed) previously introduced into the cylinder. Mr. Baldwin at first proposed to equalize the weight between the two pairs of drivers by connecting two air springs on each side by a pipe, the use of an equalizing beam being covered by Messrs. Eastwick & Harrison's patent. The air-springs were found, however, not to work practically, and were never applied. It may be added that a model of an equalizing air-spring was exhibited by Mr. Joseph Harrison, Jr., at the Franklin Institute, in 1838 or 1839.

With the introduction of the new machine, business began at once to revive, and the tide of prosperity turned once more in Mr. Baldwin's favor. Twelve engines were constructed in 1843, all but four of them of the new pattern; twenty-two engines in 1844, all of the new pattern; and twenty-seven in 1845. Three of this number were of the old type, with one pair of drivers, but from that time forward the old pattern with the single pair of drivers disappeared from the practice of the establishment, save occasionally for exceptional purposes.

In 1842, the partnership with Mr. Vail was dissolved, and Mr. Asa Whitney, who had been superintendent of the Mohawk and Hudson Railroad, became a partner with Mr. Baldwin, and the firm continued as Baldwin & Whitney until 1846, when the latter withdrew to engage in the manufacture of car-wheels, establishing the firm of A. Whitney & Sons, Philadelphia.

Mr. Whitney brought to the firm a railroad experience and thorough business talent. He introduced a system in many details of the management of the business, which Mr. Baldwin, whose mind was devoted more exclusively to mechanical subjects, had failed to establish or wholly ignored. The method at present in use in the establishment, of giving to each class of locomotives a distinctive designation, composed of a number and a letter, originated very shortly after Mr. Whitney's connection with the business. For the purpose of representing the different designs, sheets with engravings of locomotives were employed. The sheet showing the engine with one pair of drivers was marked B; that with two pairs, C; that with three, D; and that with four, E. Taking its rise from this circumstance, it became customary to designate as B engines those with one pair of drivers; as C engines, those with two pairs; as D engines, those with three pairs; and as E engines, those with four pairs. Shortly afterwards, a number, indicating the weight in gross tons, was added. Thus, the 12 D engine was one with three pairs of drivers, and weighing twelve tons; the 12 C, an engine of same weight, but with only four wheels connected. A modification of this method of designating the several plans and sizes is still in use, and is explained elsewhere.

It will be observed that the classification as thus established

began with the B engines. The letter A was reserved for an engine intended to run at very high speeds, and so designed that the driving-wheels should make two revolutions for each reciprocation of the pistons. This was to be accomplished by means of gearing. The general plan of the engine was determined in Mr. Baldwin's mind, but was never carried into execution.

The adoption of the plan of six-wheels-connected engines opened the way at once to increasing their size. The weight being almost evenly distributed on six points, heavier machines were admissible, the weight on any one pair of drivers being little, if any, greater than had been the practice with the old plan of engine having a single pair of drivers. Hence engines of eighteen and twenty tons weight were shortly introduced, and in 1844 three of twenty tons weight, with cylinders sixteen and one-half inches diameter by eighteen inches stroke, were constructed for the Western Railroad of Massachusetts, and six of eighteen tons weight, with cylinders fifteen by eighteen, and drivers forty-six inches in diameter, were built for the Philadelphia and Reading Railroad. It should be noted that three of these latter engines had iron flues. This was the first instance in which Mr. Baldwin had employed tubes of this material, although they had been previously used by others. Lap-welded iron flues were made by Morris, Tasker & Co., of Philadelphia, about 1838, and butt-welded iron tubes had previously been made by the same firm. Ross Winans, of Baltimore, had also made iron tubes by hand for locomotives of his manufacture before 1838. The advantage found to result from the use of iron tubes, apart from their less cost, was that the tubes and boiler-shell, being of the same material, expanded and contracted alike, while in the case of copper tubes the expansion of the metal by heat varied from that of the boiler shell, and as a consequence there was greater liability to leakage at the joints with the tube-sheets. The opinion prevailed largely at that time that some advantage resulted in the evaporation of water, owing to the superiority of copper as a conductor of heat. To determine this question, an experiment was tried with two of the six engines referred to above, one of which, the "Ontario," had copper flues, and another, the "New England," iron flues. In other respects they

were precisely alike. The two engines were run from Richmond to Mount Carbon, August 27, 1844, each drawing a train of one hundred and one empty cars, and, returning, from Mount Carbon to Richmond, on the following day, each with one hundred loaded cars. The quantity of water evaporated and wood consumed was noted, with the result shown in the following table:

	UP TRIP, AUG. 27, 1844.		DOWN TRIP, AUG. 28, 1844.	
	"Ontario." (Copper Flues.)	"New England." (Iron Flues.)	"Ontario." (Copper Flues.)	"New England." (Iron Flues.)
Time, running	9h. 7m.	7h. 41m.	10h. 44m.	8h. 19m.
" standing at stations	4h. 2m.	3h. 7m.	2h. 12m.	3h. 8m.
Cords of wood burned	6.68	5.50	6.94	6.
Cubic feet of water evaporated	925.75	757.26	837.46	656.39
Ratio, cubic feet of water to a cord of wood	138.57	137.68	120.67	109.39

The conditions of the experiments not being absolutely the same in each case, the results could not of course be accepted as entirely accurate. They seemed to show, however, no considerable difference in the evaporative efficacy of copper and iron tubes

The period under consideration was marked also by the introduction of the French & Baird stack, which proved at once to be one of the most successful spark-arresters thus far employed, and which was for years used almost exclusively wherever, as on the cotton-carrying railroads of the South, a thoroughly effective spark-arrester was required. This stack was introduced by Mr. Baird, then a foreman in the works, who purchased the patent-right of what had been known as the Grimes stack, and combined with it some of the features of the stack made by Mr. Richard French, then Master Mechanic of the Germantown Railroad, together with certain improvements of his own. The cone over the straight inside pipe was made with volute flanges on its under side, which gave a rotary motion to the sparks. Around the cone was a casing about six inches smaller in diameter than the outside stack. Apertures were cut in the

sides of this casing, through which the sparks in their rotary motion were discharged, and thus fell to the bottom of the space between the straight inside pipe and the outside stack. The opening in the top of the stack was fitted with a series of V-shaped iron circles perforated with numerous holes, thus presenting an enlarged area, through which the smoke escaped. The patent right for this stack was subsequently sold to Messrs. Radley & Hunter, and its essential principle is still used in the Radley & Hunter stack as at present made.

In 1845, Mr. Baldwin built three locomotives for the Royal Railroad Company of Würtemberg. They were of fifteen tons weight, on six wheels, four of them being sixty inches in diameter and coupled. The front drivers were combined by the flexible beams into a truck with the smaller leading wheels. The cylinders were inclined and outside, and the connecting-rods took hold of a half-crank axle back of the fire-box. It was specified that these engines should have the link-motion which had shortly before been introduced in England by the Stephensons. Mr. Baldwin accordingly applied a link of a peculiar character to suit his own ideas of the device. The link was made solid, and of a truncated V-section, and the block was grooved so as to fit and slide on the outside of the link.

During the year 1845 another important feature in locomotive construction—the cut-off valve—was added to Mr. Baldwin's practice. Up to that time the valve-motion had been the two eccentrics, with the single flat hook for each cylinder. Since 1841, Mr. Baldwin had contemplated the addition of some device allowing the steam to be used expansively, and he now added the "half-stroke cut-off." In this device the steam-chest was separated by a horizontal plate into an upper and a lower compartment. In the upper compartment, a valve, worked by a separate eccentric, and having a single opening, admitted steam through a port in this plate to the lower steam-chamber. The valve-rod of the upper valve terminated in a notch or hook, which engaged with the upper arm of its rock-shaft. When thus working, it acted as a cut-off at a fixed part of the stroke, determined by the setting of the eccentric. This was usually at half the stroke. When it was desired to dispense with the cut-

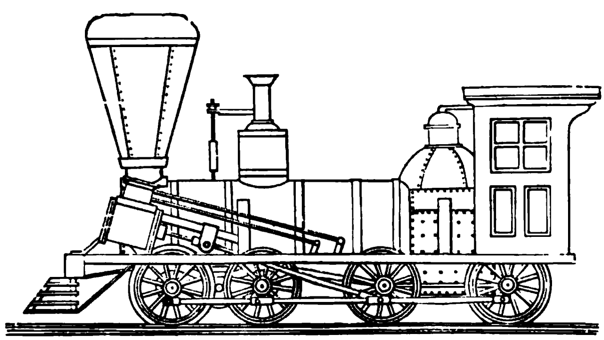
off and work steam for the full stroke, the hook of the valve-rod was lifted from the pin on the upper arm of the rock-shaft by a lever worked from the footboard, and the valve-rod was held in a notched rest fastened to the side of the boiler. This left the opening through the upper valve and the port in the partition plate open for the free passage of steam throughout the whole stroke. The first application of the half-stroke cut-off was made on the engine "Champlain" (20 D), built for the Philadelphia and Reading Railroad Company, in 1845. It at once became the practice to apply the cut-off on all passenger engines, while the six- and eight-wheels-connected freight engines were, with a few exceptions, built for a time longer with the single valve admitting steam for the full stroke.

After building, during the years 1843, 1844, and 1845, ten four-wheels-connected engines on the plan above described, viz., six wheels in all, the leading wheels and the front drivers being combined into a truck by the flexible beams, Mr. Baldwin finally adopted the present design of four drivers and a four-wheeled truck. Some of his customers who were favorable to the latter plan had ordered such machines of other builders, and Colonel Gadsden, President of the South Carolina Railroad Company, called on him in 1845 to build for that line some passenger engines of this pattern. He accordingly bought the patent-right for this plan of engine of Mr. H. R. Campbell, and for the equalizing beams used between the drivers, of Messrs. Eastwick & Harrison, and delivered to the South Carolina Railroad Company, in December, 1845, his first eight-wheeled engine with four drivers and a four-wheeled truck. This machine had cylinders thirteen and three-quarters by eighteen, and drivers sixty inches in diameter, with the springs between them arranged as equalizers. Its weight was fifteen tons. It had the half-crank axle, the cylinders being inside the frame but outside the smoke-box. The inside-connected engine, counterweighting being as yet unknown, was admitted to be steadier in running, and hence more suitable for passenger service. With the completion of the first eight-wheeled "C" engine, Mr. Baldwin's feelings underwent a revulsion in favor of this plan, and his partiality for it became as great as had been his antipathy before. Commenting

on the machine, he recorded himself as "more pleased with its appearance and action than any engine he had turned out." In addition to the three engines of this description for the South Carolina Railroad Company, a duplicate was sent to the Camden and Amboy Railroad Company, and a similar but lighter one to the Wilmington and Baltimore Railroad Company, shortly afterwards. The engine for the Camden and Amboy Railroad Company, and perhaps the others, had the half-stroke cut-off.

From that time forward all of his four-wheels-connected machines were built on this plan, and the six-wheeled "C" engine was abandoned, except in the case of one built for the Philadelphia, Germantown and Norristown Railroad Company, in 1846, and this was afterwards rebuilt into a six-wheels-connected machine. Three methods of carrying out the general design were, however, subsequently followed. At first the half-crank was used; then horizontal cylinders inclosed in the chimney-seat and working a full-crank axle, which form of construction had been practised at the Lowell Works; and eventually, outside cylinders with outside connections.

Meanwhile, the flexible truck machine maintained its popularity for heavy freight service. All the engines thus far built on this plan had been six-wheeled, some with the rear driving-axle

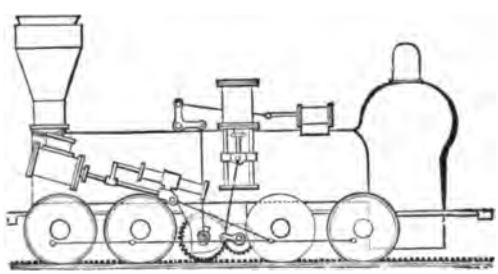


BALDWIN EIGHT-WHEELS-CONNECTED ENGINE, 1846

back of the fire-box, and others with it in front. The next step, following logically after the adoption of the eight-wheeled "C" engine, was to increase the size of the freight machine, and distribute the weight on eight wheels all connected, the two rear

pairs being rigid in the frame, and the two front pairs combined into the flexible-beam truck. This was first done in 1846, when seventeen engines on this plan were constructed on one order for the Philadelphia and Reading Railroad Company. Fifteen of these were of twenty tons weight, with cylinders fifteen and a half by twenty, and wheels forty-six inches in diameter; and two of twenty-five tons weight, with cylinders seventeen and a quarter by eighteen, and drivers forty-two inches in diameter. These engines were the first ones on which Mr. Baldwin placed sand boxes, and they were also the first built by him with roofs. On all previous engines the footboard had only been inclosed by a railing. On these engines for the Reading Railroad four iron posts were carried up, and a wooden roof supported by them. The engine-men added curtains at the sides and front, and Mr. Baldwin on subsequent engines added sides, with sash and glass. The cab proper, however, was of New England origin, where the severity of the climate demanded it, and where it had been used previous to this period.

Forty-two engines were completed in 1846, and thirty-nine in 1847. The only novelty to be noted among them was the engine "M. G. Bright," built for operating the inclined plane on the Madison and Indianapolis Railroad. The rise of this incline was one in seventeen, from the bank of the Ohio River at Madison. The engine had eight wheels, forty-two inches in diameter, connected, and worked in the usual manner by outside inclined cylinders, fifteen and one-half inches diameter by twenty inches stroke. A second pair of cylinders, seventeen inches in diameter with eighteen inches stroke of piston, was placed vertically over the boiler, midway between the furnace and smoke arch. The connecting-rods worked by these cylinders connected with cranks on a shaft



BALDWIN ENGINE FOR RACK-RAIL, 1847.

under the boiler. This shaft carried a single cog-wheel at its centre, and this cog-wheel engaged with another of about twice its diameter on a second shaft adjacent to it and in the same plane. The cog-wheel on this latter shaft worked in a rack-rail placed in the centre of the track. The shaft itself had its bearings in the lower ends of two vertical rods, one on each side of the boiler, and these rods were united over the boiler by a horizontal bar which was connected by means of a bent lever and connecting-rod to the piston worked by a small horizontal cylinder placed on top of the boiler. By means of this cylinder. the yoke carrying the shaft and cog-wheel could be depressed and held down so as to engage the cogs with the rack-rail, or raised out of the way when only the ordinary drivers were required. This device was designed by Mr. Andrew Cathcart, Master Mechanic of the Madison and Indianapolis Railroad. A similar machine, the "John Brough," for the same plane, was built by Mr. Baldwin in 1850. The incline was worked with a rack-rail and these engines until it was finally abandoned and a line with easier gradients substituted.

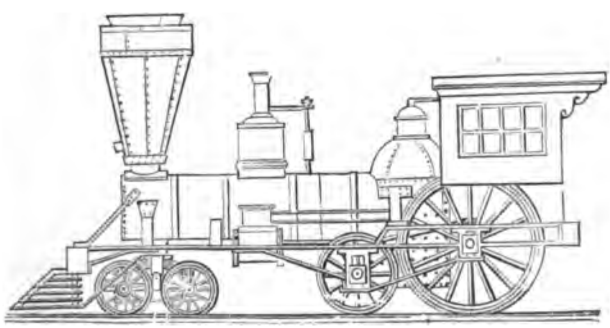
The use of iron tubes in freight engines grew in favor, and in October, 1847, Mr. Baldwin noted that he was fitting his flues with copper ends, "for riveting to the boiler."

The subject of burning coal continued to engage much attention, but the use of anthracite had not as yet been generally successful. In October, 1847, the Baltimore and Ohio Railroad Company advertised for proposals for four engines to burn Cumberland coal, and the order was taken and filled by Mr. Baldwin with four of his eight-wheels-connected machines. These engines had a heater on top of the boiler for heating the feed-water, and a grate with a rocking-bar in the centre, having fingers on each side which interlocked with projections on fixed bars, one in front and one behind. The rocking-bar was operated from the foot-board. This appears to have been the first instance of the use of a rocking-grate in the practice of these works.

The year 1848 showed a falling off in business, and only twenty engines were turned out. In the following year, however, there was a rapid recovery, and the production of the works

increased to thirty, followed by thirty-seven in 1850, and fifty in 1851. These engines, with a few exceptions, were confined to three patterns, the eight-wheeled four-coupled engine, from twelve to nineteen tons in weight, for passengers and freight, and the six- and eight-wheels-connected engine, for freight exclusively, the six-wheeled machine weighing from twelve to seventeen tons, and the eight-wheeled from eighteen to twenty-seven tons. The drivers of these six- and eight-wheels-connected machines were made generally forty-two, with occasional variations up to forty-eight inches in diameter.

The exceptions referred to in the practice of these years were the fast passenger engines built by Mr. Baldwin during this period. Early in 1848, the Vermont Central Railroad was approaching completion, and Governor Paine, the President of the Company, conceived the idea that the passenger service on the road required locomotives capable of running at very high velocities. Henry R. Campbell, Esq., was a contractor in building the line, and was authorized by Governor Paine to come to Philadelphia and offer Mr. Baldwin ten thousand dollars for a locomotive which could run with a passenger train at a speed of sixty miles per hour. Mr. Baldwin at once undertook to



BALDWIN FAST PASSENGER ENGINE, 1848.

meet these conditions. The work was begun early in 1848, and in March of that year Mr. Baldwin filed a caveat for his design. The engine was completed in 1849, and was named the "Governor Paine." It had one pair of driving-wheels, six and a half feet in diameter, placed back of the fire-box. Another pair of

wheels, but smaller and unconnected, was placed directly in front of the fire-box, and a four-wheeled truck carried the front of the engine. The cylinders were seventeen and a quarter inches diameter and twenty inches stroke, and were placed horizontally between the frames and the boiler, at about the middle of the waist. The connecting-rods took hold of "half-cranks" inside of the driving-wheels. The object of placing the cylinders at the middle of the boiler was to lessen or obviate the lateral motion of the engine, produced when the cylinders were attached to the smoke-arch. The bearings on the two rear axles were so contrived that, by means of a lever, a part of the weight of the engine usually carried on the wheels in front of the fire-box could be transferred to the driving-axle. The "Governor Paine" was used for several years on the Vermont Central Railroad, and then rebuilt into a four-coupled machine. During its career, it was stated by the officers of the road that it could be started from a state of rest and run a mile in forty-three seconds. Three engines on the same plan, but with cylinders fourteen by twenty, and six-feet driving-wheels, the "Mifflin," "Blair," and "Indiana," were also built for the Pennsylvania Railroad Company in 1849. They weighed each about forty-seven thousand pounds, distributed as follows: Eighteen thousand on the drivers, fourteen thousand on the pair of wheels in front of the fire-box, and fifteen thousand on the truck. By applying the lever, the weight on the drivers could be increased to about twenty-four thousand pounds, the weight on the wheels in front of the fire-box being correspondingly reduced. A speed of four miles in three minutes is recorded for them, and upon one occasion President Taylor was taken in a special train over the road by one of these machines at a speed of sixty miles an hour. One other engine of this pattern, the "Susquehanna," was built for the Hudson River Railroad Company in 1850. Its cylinders were fifteen inches diameter by twenty inches stroke, and drivers six feet in diameter. All these engines, however, were short-lived, and died young, of insufficient adhesion.

Eight engines with four drivers connected and half-crank axles were built for the New York and Erie Railroad Company in 1849, with seventeen by twenty-inch cylinders; one-half of the

number with six-feet and the rest with five-feet drivers. These machines were among the last on which the half-crank axle was used. Thereafter, outside-connected engines were constructed almost exclusively.

In May, 1848, Mr. Baldwin filed a caveat for a four-cylinder locomotive, but never carried the design into execution. The first instance of the use of steel axles in the practice of the establishment occurred during the same year,—a set being placed as an experiment under an engine constructed for the Pennsylvania Railroad Company. In 1850, the old form of dome-boiler, which had characterized the Baldwin engine since 1834, was abandoned, and the wagon-top form substituted.

The business in 1851, had reached the full capacity of the shop, and the next year marked the completion of about an equal number of engines (forty-nine). Contracts for work extended a year ahead, and, to meet the demand, the facilities in the various departments were increased, and resulted in the construction of sixy engines in 1853, and sixty-two in 1854.

At the beginning of the latter year, Mr. Matthew Baird, who had been connected with the works since 1836, as one of its foremen, entered into partnership with Mr. Baldwin, and the style of the firm was made M. W. Baldwin & Co.

The only novelty in the general plan of engines during this period was the addition of a ten-wheeled engine to the patterns of the establishment. The success of Mr. Baldwin's engines with all six or eight wheels connected, and the two front pairs combined by the parallel beams into a flexible truck, had been so marked that it was natural that he should oppose any other plan for freight service. The ten-wheeled engine, with six drivers connected, had, however, now become a competitor. This plan of engine was first patented by Septimus Norris, of Philadelphia, in 1846, and the original design was apparently to produce an engine which should have equal tractive power with the Baldwin six-wheels-connected machine. This the Norris patent sought to accomplish by proposing an engine with six drivers connected, and so disposed as to carry substantially the whole weight, the forward drivers being in advance of the centre of gravity of the engine, and the truck only serving as a guide,

the front of the engine being connected with it by a pivot-pin, but without a bearing on the centre-plate. Mr. Norris's first engine on this plan was tried in April, 1847, and was found not to pass curves so readily as was expected. As the truck carried little or no weight, it would not keep the track. The New York and Erie Railroad Company, of which John Brandt was then Master Mechanic, shortly afterwards adopted the ten-wheeled engine, modified in plan so as to carry a part of the weight on the truck. Mr. Baldwin filled an order for this company, in 1850, of four eight-wheels-connected engines, and in making the contract he agreed to substitute a truck for the front pair of wheels if desired after trial. This, however, he was not called upon to do.

In February, 1852, Mr. J. Edgar Thomson, President of the Pennsylvania Railroad Company, invited proposals for a number of freight locomotives of fifty-six thousand pounds weight each. They were to be adapted to burn bituminous coal, and to have six wheels connected and a truck in front, which might be either of two or four wheels. Mr. Baldwin secured the contract, and built twelve engines of the prescribed dimensions, viz., cylinders eighteen by twenty-two; drivers forty-four inches diameter, with chilled tires. Several of these engines were constructed with a single pair of truck-wheels in front of the drivers, but back of the cylinders. It was found, however, after the engines were put in service, that the two truck-wheels carried eighteen thousand or nineteen thousand pounds, and this was objected to by the company as too great a weight to be carried on a single pair of wheels. On the rest of the engines of the order, therefore, a four-wheeled truck in front was employed.

The ten-wheeled engine thereafter assumed a place in the Baldwin classification, but it was some years—not until after 1860, however—before this pattern of engine wholly superseded in Mr. Baldwin's practice the old plan of freight engine on six or eight wheels, all connected.

In 1855-56, two locomotives of twenty-seven tons weight, nineteen by twenty-two cylinders, forty-eight inch drivers, were built for the Portage Railroad, and three for the Pennsylvania Railroad. In 1855, '56, and '57, fourteen of the same dimensions

were built for the Cleveland and Pittsburg Railroad; four for the Pittsburg, Fort Wayne and Chicago Railroad; and one for the Marietta and Cincinnati Railroad. In 1858 and '59, one was constructed for the South Carolina Railroad, of the same size, and six lighter ten-wheelers, with cylinders fifteen and a half by twenty-two, and four-feet drivers, and two with cylinders sixteen by twenty-two, and four-feet drivers, were sent out to railroads in Cuba.

On three locomotives—the "Clinton," "Athens," and "Sparta"—completed for the Central Railroad of Georgia in July, 1852, the driving boxes were made with a slot or cavity in the line of the vertical bearing on the journal. The object was to produce a more uniform distribution of the wear over the entire surface of the bearing. This was the first instance in which this device, which has since come into general use, was employed in the Works, and the boxes were so made by direction of Mr. Charles Whiting, then Master Mechanic of the Central Railroad of Georgia. He subsequently informed Mr. Baldwin that this method of fitting up driving-boxes had been in use on the road for several years previous to his connection with the company. As this device was subsequently made the subject of a patent by Mr. David Matthew, these facts may not be without interest.

In 1853, Mr. Charles Ellet, Chief Engineer of the Virginia Central Railroad, laid a temporary track across the Blue Ridge, at Rock Fish Gap, for use during the construction of a tunnel through the mountain. This track was twelve thousand five hundred feet in length on the eastern slope, ascending in that distance six hundred and ten feet, or at the average rate of one in twenty and a half feet. The maximum grade was calculated for two hundred and ninety-six feet per mile, and prevailed for half a mile. It was found, however, in fact, that the grade in places exceeded three hundred feet per mile. The shortest radius of curvature was two hundred and thirty-eight feet. On the western slope, which was ten thousand six hundred and fifty feet in length, the maximum grade was two hundred and eighty feet per mile, and the ruling radius of curvature three hundred feet. This track was worked by two of the Baldwin six-wheels-connected flexible-beam truck locomotives constructed in 1853-

54. From a description of this track, and the mode of working it, published by Mr. Ellet in 1856, the following is extracted:

"The locomotives mainly relied on for this severe duty were designed and constructed by the firm of M. W. Baldwin & Company, of Philadelphia. The slight modifications introduced at the instance of the writer, to adapt them better to the particular service to be performed in crossing the Blue Ridge, did not touch the working proportions or principle of the engines, the merits of which are due to the patentee, M. W. Baldwin, Esq.

"These engines are mounted on six wheels, all of which are drivers, and coupled, and forty-two inches diameter. The wheels are set very close, so that the distance between the extreme points of contact of the wheels and the rail, of the front and rear drivers, is nine feet four inches. This closeness of the wheels, of course, greatly reduces the difficulty of turning the short curves of the road. The diameter of the cylinders is sixteen and a half inches, and the length of the stroke twenty inches. To increase the adhesion, and at the same time avoid the resistance of a tender, the engine carries its tank upon the boiler, and the footboard is lengthened out and provided with suspended side-boxes, where a supply of fuel may be stored. By this means the weight of wood and water, instead of abstracting from the effective power of the engine, contributes to its adhesion and consequent ability to climb the mountain. The total weight of these engines is fifty-five thousand pounds, or twenty-seven and a half tons, when the boiler and tank are supplied with water, and fuel enough for a trip of eight miles is on board. The capacity of the tank is sufficient to hold one hundred cubic feet of water, and it has storage-room on top for one hundred cubic feet of wood, in addition to what may be carried in the side-boxes and on the footboard.

"To enable the engines better to adapt themselves to the flexures of the road, the front and middle pairs of drivers are held in position by wrought-iron beams, having cylindrical boxes in each end for the journal-bearings, which beams vibrate on spherical pins fixed in the frame of the engine on each side, and resting on the centres of the beams. The object of this arrangement is to form a truck, somewhat flexible, which enables the drivers more readily to traverse the curves of the road.

"The writer has never permitted the power of the engines on this mountain road to be fully tested. The object has been to work the line regularly, economically, and, above all, *safely;* and these conditions are incompatible with experimental loads subjecting the machinery to severe strains. The regular daily service of each of the engines is to make four trips, of eight miles, over the mountain, drawing one eight wheel baggage car, together with two eight-wheel passenger cars, in each direction.

"In conveying freight, the regular train on the mountain is three of the eight-wheel house-cars, fully loaded, or four of them when empty or partly loaded.

"These three cars, when full, weigh, with their loads, from forty to forty-three tons. Sometimes, though rarely, when the business has been unusually heavy, the loads have exceeded fifty tons.

"With such trains the engines are stopped on the track, ascending or descending, and are started again, on the steepest grades, at the discretion of the engineer.

"Water, for the supply of the engines, has been found difficult to obtain on the mountain; and, since the road was constructed, a tank has been established on the eastern slope, where the ascending engines stop daily on a grade of two hundred and eighty feet per mile, and are there held by the brakes while the tank is being filled, and started again at the signal and without any difficulty.

"The ordinary speed of the engines, when loaded, is seven and a half miles an hour on the ascending grades, and from five and a half to six miles an hour on the descent.

"When the road was first opened, it speedily appeared that the difference of forty-three feet on the western side, and fifty-eight on the eastern side, between the grades on curves of three hundred feet radii and those on straight lines, was not sufficient to compensate for the increased friction due to such curvature. The velocity, with a constant supply of steam, was promptly retarded on passing from a straight line to a curve, and promptly accelerated again on passing from the curve to the straight line. But, after a little experience in the working of the road, it was found advisable to supply a small amount of grease to the flange of the engine by means of a sponge, saturated with oil, which, when needed, is kept in contact with the wheel by a spring. Since the use of the oil was introduced, the difficulty of turning the curves has been so far diminished, that it is no longer possible to determine whether grades of two hundred and thirty-seven and six-tenths feet per mile on curves of three hundred feet radius, or grades of two hundred and ninety-six feet per mile on straight lines, are traversed most rapidly by the engine.

"When the track is in good condition, the brakes of only two of the cars possess sufficient power to control and regulate the movement of the train,—that is to say, they will hold back the two cars and the engine. When there are three or more cars in the train, the brakes on the cars, of course, command the train so much the more easily.

"But the safety of the train is not dependent on the brakes of the car. There is also a valve or air-cock in the steam-chest, under the control of the engineer. This air-cock forms an independent brake, exclusively at the command of the engineer, and which can always be applied when the engine itself is in working order. The action of this power may be made ever so gradual, either slightly relieving the duty of the brakes on the cars, or bringing into play the entire power of the engine. The train is thus held in complete command."

The Mountain Top Track, it may be added, was worked successfully for several years, by the engines described in the above extract, until it was abandoned on the completion of the tunnel. The exceptionally steep grades and short curves which characterized the line, afforded a complete and satisfactory test of the adaptation of these machines to such peculiar service.

But the period now under consideration was marked by another, and a most important, step in the progress of American locomotive practice. We refer to the introduction of the link motion. Although this device was first employed by William T.

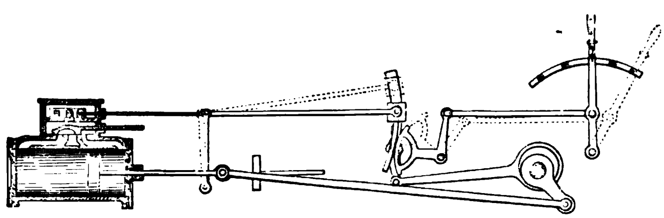
James, of New York, in 1832, and eleven years later by the Stephensons, in England, and was by them applied thenceforward on their engines, it was not until 1849 that it was adopted in this country. In that year Mr. Thomas Rogers, of the Rogers Locomotive and Machine Company, introduced it in his practice. Other builders, however, strenuously resisted the innovation, and none more so than Mr. Baldwin. The theoretical objections which confessedly apply to the device, but which practically have been proved to be unimportant, were urged from the first by Mr. Baldwin as arguments against its use. The strong claim of the advocates of the link-motion, that it gave a means of cutting off steam at any point of the stroke, could not be gainsaid, and this was admitted to be a consideration of the first importance. This very circumstance undoubtedly turned Mr. Baldwin's attention to the subject of methods for cutting off steam, and one of the first results was his "Variable Cut-off," patented April 27, 1852. This device consisted of two valves, the upper sliding upon the lower, and worked by an eccentric and rock-shaft in the usual manner. The lower valve fitted steam-tight to the sides of the steam-chest and the under surface of the uppper valve. When the piston reached each end of its stroke, the full pressure of steam from the boiler was admitted around the upper valve, and transfered the lower valve instantaneously from one end of the steam-chest to the other. The openings through the two valves were so arranged that steam was admitted to the cylinder only for a part of the stroke. The effect was, therefore, to cut off steam at a given point, and to open the induction and exhaust ports substantially at the same instant and to their full extent. The exhaust port, in addition, remained fully opened while the induction port was gradually closing, and after it had entirely closed. Although this device was never put in use, it may be noted in passing that it contained substantially the principle of the steam-pump, as since patented and constructed.

Early in 1853, Mr. Baldwin abandoned the half-stroke cut-off, previously described, and which he had been using since 1845, and adopted the variable cut-off, which was already employed by other builders. One of his letters, written in January, 1853, states his position, as follows:

"I shall put on an improvement in the shape of a variable cut-off, which can be operated by the engineer while the machine is running, and which will cut off anywhere from six to twelve inches, according to the load and amount of steam wanted, and this without the link-motion, which I could never be entirely satisfied with. I still have the independent cut-off, and the additional machinery to make it variable will be simple and not liable to be deranged."

This form of cut-off was a separate valve, sliding on a partition plate between it and the main steam-valve, and worked by an independent eccentric and rock-shaft. The upper arm of the rock-shaft was curved so as to form a radius-arm, on which a sliding-block, forming the termination of the upper valve-rod, could be adjusted and held at varying distances from the axis, thus producing a variable travel of the upper valve. This device did not give an absolutely perfect cut-off, as it was not operative in backward gear, but when running forward it would cut off with great accuracy at any point of the stroke, was quick in its movement, and economical in the consumption of fuel.

After a short experience with this arrangement of the cut-off, the partition plate was omitted, and the upper valve was made to slide directly on the lower. This was eventually found objectionable, however, as the lower valve would soon cut a hollow in the valve-face. Several unsuccessful attempts were made to remedy this defect by making the lower valve of brass, with long bearings, and making the valve-face of the cylinder of hardened steel; finally, however, the plan of one valve on the other was aban-



Variable Cut-off Adjustment.

doned, and a recourse was again had to an interposed partition plate, as in the original half-stroke cut-off.

Mr. Baldwin did not adopt this form of cut-off without some modification of his own, and the modification in this instance consisted of a peculiar device, patented September 13, 1835, for rais-

ing and lowering the block on the radius-arm. A quadrant was placed so that its circumference bore nearly against a curved arm projecting down from the sliding-block, and which curved in the reverse direction from the quadrant. Two steel straps side by side were interposed between the quadrant and this curved arm. One of the straps was connected to the lower end of the quadrant and the upper end of the curved arm; the other, to the upper end of the quadrant and the lower end of the curved arm. The effect was the same as if the quadrant and arm geared into each other in any position by teeth, and theoretically the block was kept steady in whatever position placed on the radius-arm of the rock-shaft. This was the object sought to be accomplished, and was stated in the specification of the patent as follows:

"The principle of varying the cut-off by means of a vibrating arm and sliding pivot-block has long been known, but the contrivances for changing the position of the block upon the arm have been very defective. The radius of motion of the link by which the sliding-block is changed on the arm, and the radius of motion of that part of the vibrating arm on which the block is placed, have, in this kind of valve gear, as heretofore constructed, been different, which produced a continual rubbing of the sliding-block upon the arm while the arm is vibrating; and as the block for the greater part of the time occupies one position on the arm, and only has to be moved towards either extremity occasionally, that part of the arm on which the block is most used soon becomes so worn that the block is loose, and jars."

This method of varying the cut-off was first applied on the engine "Belle," delivered to the Pennsylvania Railroad Company, December 6, 1854, and thereafter was for some time employed by Mr. Baldwin. It was found, however, in practice that the steel straps would stretch sufficiently to allow them to buckle and break, and hence they were soon abandoned, and chains substituted between the quadrant and curved arm of the sliding-block. These chains in turn proved little better, as they lengthened, allowing lost motion, or broke altogether, so that eventually the quadrant was wholly abandoned, and recourse was finally had to the lever and link for raising and lowering the sliding-block. As thus arranged, the cut-off was substantially what was known as the "Cuyahoga Cut-off," as introduced by Mr. Ethan Rogers, of the Cuyahoga Works, Cleveland, Ohio, except that Mr. Baldwin used a partition plate between the upper and the lower valve.

But while Mr. Baldwin, in common with many other builders, was thus resolutely opposing the link-motion, it was nevertheless rapidly gaining favor with Railroad managers. Engineers and master mechanics were everywhere learning to admire its simplicity, and were manifesting an enthusiastic preference for engines so constructed. At length, therefore, he was forced to succumb; and the link was applied to the "Pennsylvania," one of two engines completed for the Central Railroad of Georgia, in February, 1854. The other engine of the order, the "New Hampshire," had the variable cut-off, and Mr. Baldwin, while yielding to the demand in the former engine, was undoubtedly sanguine that the working of the latter would demonstrate the inferiority of the new device. In this, however, he was disappointed, for in the following year the same company ordered three more engines, on which they specified the link-motion. In 1856 seventeen engines for nine different companies had this form of valve-gear, and its use was thus incorporated in his practice. It was not, however, until 1857 that he was induced to adopt it exclusively.

February 14, 1854, Mr. Baldwin and Mr. David Clark, Master Mechanic of the Mine Hill Railroad, took out conjointly a patent for a feed-water heater, placed at the base of a locomotive chimney, and consisting of one large vertical flue, surrounded by a number of smaller ones. The exhaust steam was discharged from the nozzles through the large central flue, creating a draft of the products of combustion through the smaller surrounding flues. The pumps forced the feed-water into the chamber around these flues, whence it passed to a boiler by the pipe from the back of the stack. This heater was applied on several engines for the Mine Hill Railroad, and on a few other roads; but its use was exceptional, and lasted only for a year or two.

In December of the same year, Mr. Baldwin filed a caveat for a variable exhaust, operated automatically, by the pressure of steam, so as to close when the pressure was lowest in the boiler, and open with the increase of pressure. The device was never put in service.

The use of coal, both bituminous and anthracite, as a fuel for locomotives, had by this time become a practical success. The

economical combustion of bituminous coal, however, engaged considerable attention. It was felt that much remained to be accomplished in consuming the smoke and deriving the maximum of useful effect from the fuel. Mr. Baird, who was now associated with Mr. Baldwin in the management of the business, made this matter a subject of careful study and investigation. An experiment was conducted under his direction, by placing a sheet-iron deflector in the fire-box of an engine on the Germantown and Norristown Railroad. The success of the trial was such as to show conclusively that a more complete combustion resulted. As, however, a deflector formed by a single plate of iron would soon be destroyed by the action of the fire, Mr. Baird proposed to use a water-leg projecting upward and backward from the front of the fire-box under the flues. Drawings and a model of the device were prepared, with a view of patenting it, but subsequently the intention was abandoned, Mr. Baird concluding that a fire-brick arch as a deflector to accomplish the same object was preferable. This was accordingly tried on two locomotives built for the Pennsylvania Railroad Company in 1854, and was found so valuable an appliance that its use was at once established, and it was put on a number of engines built for railroads in Cuba and elsewhere. For several years the fire-bricks were supported on side plugs; but in 1858, in the "Media," built for the West Chester and Philadelphia Railroad Company, water-pipes extending from the crown obliquely downward and curving to the sides of the fire-box at the bottom were successfully used for the purpose.

The adoption of the link-motion may be regarded as the dividing line between the present and the early and transitional stage of locomotive practice. Changes since that event have been principally in matters of detail, but it is the gradual perfection of these details which has made the locomotive the symmetrical, efficient, and wonderfully complete piece of mechanism it is today. In perfecting these minutiæ, the Baldwin Locomotive Works has borne its part, and it only remains to state briefly its contributions in this direction.

The production of the establishment during the six years from 1855 to 1860, inclusive, was as follows: forty-seven engines in

1855; fifty-nine in 1856; sixty-six in 1857; thirty-three in 1858; seventy in 1859; and eighty-three in 1860. The greater number of these were of the ordinary type, four drivers coupled, and a four-wheeled truck, and varying in weight from fifteen ton engines, with cylinders twelve by twenty-two, to twenty-seven ton engines, with cylinders sixteen by twenty-four. A few ten-wheeled engines were built, as has been previously noted, and the remainder were the Baldwin flexible-truck six- and eight-wheels-connected engines. The demand for these, however, was now rapidly falling off, the ten-wheeled and heavy "C" engines taking their place, and by 1859 they ceased to be built, save in exceptional cases, as for some foreign roads, from which orders for this pattern were still occasionally received.

A few novelties characterizing the engines of this period may be mentioned. Several engines built in 1855 had cross-flues placed in the fire-box, under the crown, in order to increase the heating surface. This feature, however, was found impracticable, and was soon abandoned. The intense heat to which the flues were exposed converted the water contained in them into highly superheated steam, which would force its way out through the water around the fire-box with violent ebullitions. Four engines were built for the Pennsylvania Railroad Company, in 1856-57, with straight boilers and two domes. The "Delano" grate, by means of which the coal was forced into the fire-box from below, was applied on four ten-wheeled engines for the Cleveland and Pittsburg Railroad in 1857. In 1859 several engines were built with the form of boiler introduced on the Cumberland Valley Railroad in 1851 by Mr. A. F. Smith, and which consisted of a combustion-chamber in the waist of the boiler, next the fire-box. This form of boiler was for some years thereafter largely used in engines for soft coal. It was at first constructed with the "water-leg," which was a vertical water-space, connecting the top and bottom sheets of the combustion-chamber, but eventually this feature was omitted, and an unobstructed combustion-chamber employed. Several engines were built for the Philadelphia, Wilmington and Baltimore Railroad Company in 1859, and thereafter, with the "Dimpfel" boiler, in which the tubes contain water, and, starting downward from the crown-sheet, are curved to the hori-

zontal, and terminate in a narrow water-space next the smoke-box. The whole waist of the boiler, therefore, forms a combustion-chamber, and the heat and gases, after passing for their whole length along and around the tubes, emerge into the lower part of the smoke-box.

In 1860 an engine was built for the Mine Hill Railroad, with a boiler of a peculiar form. The top sheets sloped upward from both ends towards the centre, thus making a raised part or hump in the centre. The engine was designed to work on heavy grades, and the object sought by Mr. Wilder, the Superintendent of the Mine Hill Railroad, was to have the water always at the same height in the space from which steam was drawn, whether going up or down grade.

All these experiments are indicative of the interest then prevailing upon the subject of coal-burning. The result of experience and study had meantime satisfied Mr. Baldwin that to burn soft coal successfully required no peculiar devices; that the ordinary form of boiler, with plain fire-box, was right, with perhaps the addition of a fire-brick deflector; and that the secret of the economical and successful use of coal was in the mode of firing, rather than in a different form of furnace.

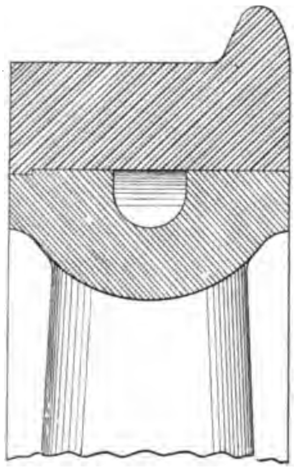
The year 1861 witnessed a marked falling off in the production. The breaking out of the Civil War at first unsettled business, and by many it was thought that railroad traffic would be so largely reduced that the demand for locomotives must cease altogether. A large number of hands were discharged from the Works, and only forty locomotives were turned out during the year. It was even seriously contemplated to turn the resources of the establishment to the manufacture of shot and shell, and other munitions of war, the belief being entertained that the building of locomotive would have to be altogether suspended. So far, however, was this from being the case, that, after the first excitement had subsided, it was found that the demand for transportation by the general government, and by the branches of trade and production stimulated by the war, was likely to tax the carrying capacity of the principal Northern railroads to the fullest extent. The government itself became a large purchaser of locomotives, and it is noticeable, as indicating the increase of travel and freight

transportation, that heavier machines than had ever before been built became the rule. Seventy-five engines were sent from the works in 1862; ninety-six in 1863; one hundred and thirty in 1864; and one hundred and fifteen in 1865. During two years of this period, from May, 1862, to June, 1864, thirty-three engines were built for the United States Military Railroads. The demand from the various coal-carrying roads in Pennsylvania and vicinity was particularly active, and large numbers of ten-wheeled engines, and of the heaviest eight-wheeled four-coupled engines, were built. Of the latter class, the majority were fifteen- and sixteen-inch cylinders, and of the former, seventeen- and eighteen-inch cylinders.

The introduction of several important features in construction marks this period. Early in 1861, four eighteen-inch cylinder freight locomotives, with six coupled wheels, fifty-two inches in diameter, and a Bissell pony-truck with radius-bar in front, were sent to the Louisville and Nashville Railroad Company. This was the first instance of the use of the Bissell truck in the Baldwin Works. These engines, however, were not of the regular "Mogul" type, as they were only modifications of the ten-wheeler, the drivers retaining the same position well back, and a pair of pony-wheels on the Bissell plan taking the place of the ordinary four-wheeled truck. Other engines of the same pattern, but with eighteen and one-half inch cylinders, were built in 1862-63, for the same company, and for the Dom Pedro II. Railway of Brazil.

The introduction of steel in locomotive-construction was a distinguishing feature of the period. Steel tires were first used in the works in 1862, on some engines for the Dom Pedro II. Railway of South America. Their general adoption on American Railroads followed slowly. No tires of this material were then made in this country, and it was objected to their use that, as it took from sixty to ninety days to import them, an engine, in case of a breakage of one of its tires, might be laid up useless for several months. To obviate this objection M. W. Baldwin & Co. imported five hundred steel tires, most of which were kept in stock, from which to fill orders. The steel tires as first used in 1862 on the locomotives for the Dom Pedro Segundo Railway

were made with a "shoulder" at one edge of the internal periphery, and were shrunk on the wheel-centres. The sketch below shows a section of the tire as then used.



Steel Tire, with Shoulder.

Steel fire-boxes were first built for some engines for the Pennsylvania Railroad Company in 1861. English steel of a high temper was used, and at the first attempt the fire-boxes cracked in fitting them in the boilers, and it became necessary to take them out and substitute copper. American homogeneous cast-steel was then tried on engines 231 and 232, completed for the Pennsylvania Railroad in January, 1862, and it was found to work successfully. The fire-boxes of nearly all engines thereafter built for that road were of this material, and in 1866 its use for the purpose became general. It may be added that while all steel sheets for fire-boxes or boilers are required to be thoroughly annealed before delivery, those which are flanged or worked in the process of boiler construction are a second time annealed before riveting.

Another feature of construction gradually adopted was the placing of the cylinders horizontally. This was first done in the case of an outside-connected engine, the "Ocmulgee," which was sent to the Southwestern Railroad Company of Georgia, in January, 1858. This engine had a square smoke-box, and the cylinders were bolted horizontally to its sides. The plan of casting the cylinder and half-saddle in one piece and fitting it to the round smoke-box was introduced by Mr. Baldwin, and grew naturally out of his original method of construction. Mr. Baldwin was the first American builder to use an outside cylinder, and he made it for his early engines with a circular flange cast to it, by which it could be bolted to the boiler. The cylinders were gradually brought lower, and at a less angle, and the flanges prolonged and enlarged. In 1852, three six-wheels-

connected engines, for the Mine Hill Railroad Company, were built with the cylinder flanges brought around under the smoke-box until they nearly met, the space between them being filled with a spark-box. This was practically equivalent to making the cylinder and half-saddle in one casting. Subsequently, on other engines on which the spark-box was not used, the half-saddles were cast so as almost to meet under the smoke-box, and, after the cylinders were adjusted in position, wedges were fitted in the interstices and the saddles bolted together. It was finally discovered that the faces of the two half-saddles might be planed and finished so that they could be bolted together and bring the cylinders accurately in position, thus avoiding the troublesome and tedious job of adjusting them by chipping and fitting to the boiler and frames. With this method of construction, the cylinders were placed at a less and less angle, until at length the truck-wheels were spread sufficiently, on all new or modified classes of locomotives in the Baldwin list, to admit of the cylinders being hung horizontally, as is the present almost universal American practice. By the year 1865 horizontal cylinders were made in all cases where the patterns would allow it. The advantages of this arrangement are manifestly in the interest of simplicity and economy, as the cylinders are thus rights or lefts, indiscriminately, and a single pattern answers for either side.

A distinguishing feature in the method of construction which characterizes these works is the extensive use of a system of standard gauges and templates, to which all work admitting of this process is required to be made. The importance of this arrangement, in securing absolute uniformity of essential parts in all engines of the same class, is manifest, and with the increased production since 1861 it became a necessity as well as a decided advantage. It has already been noted that as early as 1839, Mr. Baldwin felt the importance of making all like parts of similar engines absolutely uniform and interchangeable. It was not attempted to accomplish this object, however, by means of a complete sytem of standard gauges, until many years later. In 1861 a beginning was made of organizing all the departments of manufacture upon this basis, and from it has since grown an

elaborate and perfected system, embracing all the essential details of construction. An independent department of the works, having a separate foreman and an adequate force of skilled workmen with special tools adapted to the purpose, is organized as the Department of Standard Gauges. A system of standard gauges and templates for every decription of work to be done is made and kept by this department. The original templates are kept as "standards," and are never used on the work itself, but from them exact duplicates are made, which are issued to the foremen of the various departments, and to which all work is required to conform. The working gauges are compared with the standards at regular intervals, and absolute uniformity is thus maintained. The system is carried into every possible important detail. Frames are planed and slotted to gauges, and drilled to steel bushed templets. Cylinders are bored and planed, and steam-ports, with valves and steam-chests, finished and fitted, to gauges. Tires are bored, centres turned, axles finished, and cross-heads, guides, guide-bearers, pistons, connecting- and parallel-rods planed, slotted, or finished by the same method. Every bolt about the engine is made to a gauge, and every hole drilled and reamed to a templet. The result of the system is an absolute uniformity and interchangeableness of parts in engines of the same class, insuring to the purchaser the minimum cost of repairs, and rendering possible, by the application of this method, the large production which these works have accomplished.

Thus had been developed and perfected the various essential details of existing locomotive practice when Mr. Baldwin died, September 7, 1866. He had been permitted, in a life of unusual activity and energy, to witness the rise and wonderful increase of a material interest which had become the distinguishing feature of the century. He had done much, by his own mechanical skill and inventive genius, to contribute to the development of that interest. His name was as "familiar as household words" wherever on the American continent the locomotive had penetrated. An ordinary ambition might well have been satisfied with this achievement. But Mr. Baldwin's claim to the remembrance of his fellow-men rests not alone on the results of his

mechanical labors. A merely technical history, such as this, is not the place to do justice to his memory as a man, as a Christian, and as a philanthropist; yet the record would be manifestly imperfect, and would fail properly to reflect the sentiments of his business associates who so long knew him in all relations of life, were no reference made to his many virtues and noble traits of character. Mr. Baldwin was a man of sterling integrity and singular conscientiousness. To do right, absolutely and unreservedly, in all his relations with men, was an instinctive rule of his nature. His heroic struggle to meet every dollar of his liabilities, principal and interest, after his failure, consequent upon the general financial crash in 1837, constitutes a chapter of personal self-denial and determined effort which is seldom paralleled in the annals of commercial experience. When most men would have felt that an equitable compromise with creditors was all that could be demanded in view of the general financial embarrassment, Mr. Baldwin insisted upon paying all claims in full, and succeeded in doing so only after nearly five years of unremitting industry, close economy, and absolute personal sacrifices. As a philanthropist and a sincere and earnest Christian, zealous in every good work, his memory is cherished by many to whom his contributions to locomotive improvement are comparatively unknown. From the earliest years of his business life the practice of systematic benevolence was made a duty and a pleasure. His liberality constantly increased with his means. Indeed, he would unhesitatingly give his notes, in large sums, for charitable purposes when money was absolutely wanted to carry on his business. Apart from the thousands which he expended in private charities, and of which, of course, little can be known, Philadelphia contains many monuments of his munificence. Early taking a deep interest in all Christian effort, his contributions to missionary enterprise and church extension were on the grandest scale, and grew with increasing wealth. Numerous church edifices in this city, of the denomination to which he belonged, owe their existence largely to his liberality, and two at least were projected and built by him entirely at his own cost. In his mental character, Mr. Baldwin was a man of remarkable firmness of purpose. This trait was strongly shown during his

mechanical career in the persistency with which he would work at a new improvement or resist an innovation. If he was led sometimes to assume an attitude of antagonism to features of locomotive-construction which after-experience showed to be valuable,—and a desire for historical accuracy has required the mention, in previous pages, of several instances of this kind,—it is at least certain that his opposition was based upon a conscientious belief in the mechanical impolicy of the proposed changes.

After the death of Mr. Baldwin the business was reorganized, in 1867, under the title of "The Baldwin Locomotive Works," M. Baird & Co., Proprietors. Messrs. George Burnham and Charles T. Parry, who had been connected with the establishment from an early period, the former in charge of the finances, and the latter as General Superintendent, were associated with Mr. Baird in the copartnership. Three years later, Messrs. Edward H. Williams, Wiliam P. Henszey, and Edward Longstreth became members of the firm. Mr. Williams had been connected with railway management on various lines since 1850. Mr. Henszey had been Mechanical Engineer, and Mr. Longstreth the General Superintendent of the works for several years previously.

The production of the Baldwin Locomotive Works from 1866 to 1871, both years inclusive, was as follows:

1866, one hundred and eighteen locomotives.
1867, one hundred and twenty-seven "
1868, one hundred and twenty-four "
1869, two hundred and thirty-five "
1870, two hundred and eighty "
1871, three hundred and thirty-one "

In July, 1866, the engine "Consolidation" was built for the Lehigh Valley Railroad, on the plan and specification furnished by Mr. Alexander Mitchell, Master Mechanic of the Mahanoy Division of that Railroad. This engine was intended for working the Mahanoy plane, which rises at the rate of one hundred and thirty-three feet per mile. The "Consolidation" had cylinders twenty by twenty-four, four pairs of drivers connected, forty-eight

inches in diameter, and a Bissell pony-truck in front, equalized with the front drivers. The weight of the engine, in working order, was ninety thousand pounds, of which all but about ten thousand pounds was on the drivers. This engine has constituted the first of a class to which it has given its name, and "Consolidation" engines have since been constructed for a large number of railways, not only in the United States, but in Mexico, Brazil, and Australia. Later engines of the class for the four feet eight and a half inch gauge have, however, been made heavier.


"CONSOLIDATION."

A class of engines known as "Moguls," with three pairs of drivers connected and a swinging pony-truck in front equalized with the forward drivers, took its rise in the practice of this establishment from the "E. A. Douglas," built for the Thomas Iron Company in 1867. These engines are fully illustrated in the catalogue. Several sizes of "Moguls" have been built, but principally with cylinders sixteen to nineteen inches in diameter, and twenty-two or twenty-four inches stroke, and with drivers from forty-four to fifty-seven inches in diameter. This plan of engine has rapidly grown in favor for freight service on heavy grades or where maximum loads are to be moved, and has been adopted by several leading lines. Utilizing, as it does, nearly the entire weight of the engine for adhesion, the main and back pairs of drivers being equalized together, as also the front drivers and the pony-wheels, and the construction of the engine with swing-truck and one pair of drivers without flanges allowing it to pass short curves without difficulty, the "Mogul" is generally accepted as a type of engine especially adapted to the economical working of heavy freight traffic.


"MOGUL."

In 1867, on a number of eight-wheeled four-coupled engines for the Pennsylvania Railroad, the four-wheeled swing-bolster-truck was first applied, and thereafter a large number of engines have been so constructed. The two-wheeled or "pony-truck" has been built both on the Bissell plan, with double inclined slides, and with the ordinary swing-bolster, and in both cases with the radius-bar pivoting from a point about four feet back from the centre of the truck. The four-wheeled truck has been made with swinging or sliding bolster, and both with and without the radius-bar. Of the engines above referred to as the first on which the swing-bolster-truck was applied, four were for express passenger service, with drivers sixty-seven inches in diameter, and cylinders seventeen by twenty-four. One of them, placed on the road September 9, 1867, was in constant service until May 14, 1871, without ever being off its wheels for repairs, making a total mileage of one hundred and fifty-three thousand two hundred and eighty miles. All of these engines have their driving-wheels spread eight and one-half feet between centres.

Steel flues were first used in three ten-wheeled freight engines, Numbers 211, 338, and 368, completed for the Pennsylvania Railroad in August, 1868. Steel boilers were first made in 1868 for locomotives for the Pennsylvania Railroad Company, and the use of this material for the barrels of boilers as well as for the fire-boxes has now become universal in American practice.

In 1854, four engines for the Pennsylvania Railroad Company, the "Tiger," "Leopard," "Hornet," and "Wasp," were built with straight boilers and two domes each, and in 1866 this method of construction was revived, and until about 1880 the practice of the establishment included both the wagon-top boiler with single dome, and the straight boiler with one or two domes. When the straight boiler is used the waist is made about two inches larger in diameter than that of the wagon-top form. About equal space for water and steam is thus given in either case, and, as the number of flues is the same in both forms, more room for the circulation of water between the flues is afforded in the straight boiler on account of its larger diameter, than in the wagon-top shape. Since 1880 the use of two domes has been

exceptional, both wagon-top and straight boilers being constructed with one dome.

In 1868, a locomotive of three and a half feet gauge was constructed for the Averill Coal and Oil Company, of West Virginia. This was the first narrow-gauge locomotive in the practice of the Works.

In 1869 three locomotives of the same gauge were constructed for the União Valenciana Railway of Brazil, and were the first narrow-gauge locomotives constructed at these Works for general passenger and freight traffic. In the following year the Denver and Rio Grande Railway, of Colorado, was projected on the three-feet gauge, and the first locomotives for the line were designed and built in 1871. Two classes, for passenger and freight respectively, were constructed. The former were six-wheeled, four wheels coupled forty inches in diameter, nine by sixteen cylinders, and weighed each, loaded, about twenty-five thousand pounds. The latter were eight-wheeled, six-wheels coupled thirty-six inches in diameter, eleven by sixteen cylinders, and weighed each, loaded, about thirty-five thousand pounds. Each had a swinging-truck of a single pair of wheels in front of the cylinders. The latter type has been maintained for freight service up to the present time, but principally of larger sizes, engines as heavy as fifty thousand pounds having been turned out. The former type for passenger service was found to be too small and to be unsteady on the track, owing to its comparatively short wheel-base. It was therefore abandoned, and the ordinary "American" pattern, eight-wheeled, four-coupled, substituted. Following the engines for the Denver and Rio Grande Railway, others for other narrow-gauged lines were called for, and the manufacture of this description of rolling stock soon assumed importance.

The "Consolidation" type, as first introduced for the four feet eight and one-half inches gauge in 1866, was adapted to the three-feet gauge in 1873. In 1877 a locomotive on this plan, weighing in working order about sixty thousand pounds, with cylinders fifteen by twenty, was built for working the Garland extension of the Denver and Rio Grande Railway, which crosses the Rocky Mountains with maximum grades of two hundred

and eleven feet per mile, and minimum curves of thirty degrees. The performance of this locomotive, the "Alamosa," is given in the following extract from a letter from the then General Superintendent of that railway:

"DENVER, COL., Aug. 31, 1877.

"On the 29th inst. I telegraphed you from Veta Pass—Sangre de Cristo Mountains—that engine 'Alamosa' had just hauled from Garland to the Summit one baggage car and seven coaches, containing one hundred and sixty passengers. Yesterday I received your reply asking for particulars, etc.

"My estimate of the weight was eighty-five net tons, stretched over a distance of three hundred and sixty feet, or including the engine, of four hundred and five feet.

"The occasion of this sized train was an excursion from Denver to Garland and return. The night before, in going over from La Veta, we had over two hundred passengers, but it was 8 P.M., and, fearing a slippery rail, I put on engine No. 19 as a pusher, although the engineer of the 'Alamosa' said he could haul the train, and I believe he could have done so. The engine and train took up a few feet more than the half circle at 'Mule Shore,' where the radius is one hundred and ninety-three feet. The engine worked splendidly, and moved up the two hundred and eleven feet grades and around the thirty degree curves seemingly with as much ease as our passenger engines on 75 feet grades with three coaches and baggage cars.

"The 'Alamosa' hauls regularly eight loaded cars and caboose, about one hundred net tons; length of train about two hundred and thirty feet.

"The distance from Garland to Veta Pass is fourteen and one quarter miles, and the time is one hour and twenty minutes.

"Respectfully yours,

(Signed) "W. W. BORST, *Sup't.*"

In addition to narrow-gauge locomotives for the United States, this branch of the product has included a large number of one-metre gauge locomotives for Brazil, three-feet gauge locomotives for Cuba, Mexico, and Peru, and three and one-half feet gauge stock for Costa Rica, Nicaragua, Canada, and Australia.

Locomotives for single-rail railroads were built in 1878 and early in 1879, adapted respectively to the systems of General Roy Stone and Mr. W. W. Riley.

Mine locomotives, generally of narrow-gauge, for underground work, and not over five and one-half feet in height, were first built in 1870. These machines have generally been four-wheels connected, with inside cylinders and a crank-axle. The width over all of this plan is only sixteen inches greater than the gauge of the track. A number of outside-connected mine locomotives have, however, also been constructed. In this

pattern the width is thirty-two inches greater than the gauge of the track. A locomotive of twenty inches gauge for a gold mine in California was built in 1876, and was found entirely practicable and efficient.

In 1870, in some locomotives for the Kansas Pacific Railway, the steel tires were shrunk on without being secured by bolts or rivets in any form, and since that time this method of putting on tires has been the rule.

In 1871 forty locomotives were constructed for the Ohio and Mississippi Railway, the gauge of which was changed from five feet six inches to four feet eight and one-half inches. The entire lot of forty locomotives was completed and delivered in about twelve weeks. The gauge of the road was changed on July 4, and the forty locomotives went at once into service in operating the line on the standard gauge.

During the same year two "double-end" engines of Class 10-26¼ C were constructed for the Central Railroad of New Jersey, and were the first of this pattern at these Works.

The product of the Works, which had been steadily increasing for some years in sympathy with the requirements of the numerous new railroads which were constructing, reached three hundred and thirty-one locomotives in 1871, and four hundred and twenty-two in 1872. Orders for ninety locomotives for the Northern Pacific Railroad were entered during 1870-71, and for one hundred and twenty-four for the Pennsylvania Railroad during 1872-73, and mostly executed during those years. A contract was also made during 1872 with the Veronej-Rostoff Railway of Russia for ten locomotives to burn Russian anthracite coal. Six were "Moguls," with cylinders nineteen by twenty-four, and driving-wheels four and one-half feet diameter; and four were passenger locomotives, "American" pattern, with cylinders seventeen by twenty-four, and driving-wheels five and one-half feet diameter. Nine "American" pattern locomotives, fifteen by twenty-four cylinders, and five feet driving-wheels, were also constructed in 1872-73 for the Hango-Hyvinge Railway of Finland.

Early in 1873, Mr. Baird retired from the business, having sold his interest in the Works to his five partners. Mr. Baird died

May 19, 1877. A new firm was formed under the style of Burnham, Parry, Williams & Co., dating from January 1, 1873, and Mr. John H. Converse, who had been connected with the Works since 1870, became a partner. The product of this year was four hundred and thirty-seven locomotives, the greatest in the history of the business. During a part of the year ten locomotives per week were turned out. Nearly three thousand men were employed. Forty-five locomotives for the Grand Trunk Railway of Canada were built in August, September, and October, 1873, and all were delivered in five weeks after shipment of the first. As in the case of the Ohio and Mississippi Railway, previously noted, these were to meet the requirements of a change of gauge from five and one-half feet to four feet eight and one-half inches. In November, 1873, under circumstances of especial urgency, a small locomotive for the Meier Iron Company of St. Louis was wholly made from the raw material in sixteen working days.

The financial difficulties which prevailed throughout the United States, beginning in September, 1873, and affecting chiefly the railroad interests and all branches of manufacture connected therewith, have operated of course to curtail the production of locomotives since that period. Hence, only two hundred and five locomotives were built in 1874, and one hundred and thirty in 1875. Among these may be enumerated two sample locomotives for burning anthracite coal (one passenger, sixteen by twenty-four cylinders, and one "Mogul" freight, eighteen by twenty-four cylinders) for the Technical Department of the Russian Government; also, twelve "Mogul" freight locomotives, nineteen by twenty-four cylinders, for the Charkoff Nicolaieff Railroad of Russia. A small locomotive to work by compressed air, for drawing street-cars, was constructed during 1874 for the Compressed Air Locomotive and Street-Car Company of Louisville, Ky. It had cylinders seven by twelve, and four wheels coupled, thirty inches in diameter. Another and smaller locomotive to work by compressed air was constructed three years later for the Plymouth Cordage Company of Massachusetts, for service on a track in and about their works. It had cylinders five by ten, four wheels coupled twenty-four inches diameter,

weight seven thousand pounds, and has been successfully employed for the work required.

The year 1876, noted as the year of the Centennial International Exhibition in Philadelphia, brought some increase of business, and two hundred and thirty-two locomotives were constructed. An exhibit consisting of eight locomotives was prepared for this occasion. With the view of illustrating not only the different types of American locomotives, but the practice of different railroads, the exhibit consisted chiefly of locomotives constructed to fill orders from various railroad companies of the United States, and from the Imperial Government of Brazil. A "Consolidation" locomotive for burning anthracite coal, for the Lehigh Valley Railroad, for which line the first locomotive of this type was designed and built in 1866; a similar locomotive, to burn bituminous coal, and a passenger locomotive for the same fuel for the Pennsylvania Railroad; a "Mogul" freight locomotive, the "Principe do Grão Pará," for the Dom Pedro Segundo Railway of Brazil; and a passenger locomotive (anthracite burner) for the Central Railroad of New Jersey, comprised the larger locomotives contributed by these Works to the Exhibition of 1876. To these were added a mine locomotive and two narrow (three feet) gauge locomotives which were among those used in working the Centennial Narrow-Gauge Railway. As this line was in many respects unique, we subjoin the folowing extracts from an account by its General Manager of the performance of the two three-feet gauge locomotives:

"The gauge of the line was three feet, with double track three and a half miles long, or seven miles in all. For its length it was probably the most crooked road in the world, being made up almost wholly of curves, in order to run near all the principal buildings on the Exhibition grounds. Many of these curves were on our heaviest grades, some having a radius of 215, 230 and 250 feet on grades of 140 and 155 feet per mile. These are unusually heavy grades and curves, and when *combined* as we had them, with only a thirty-five pound iron rail, made the task for our engines exceedingly difficult.

"Your locomotive 'Schuylkill,' Class 8-18 C (eight-wheeled, four wheels coupled three and a half feet diameter, cylinders twelve by sixteen, weight forty-two thousand six hundred and fifty pounds), began service May 13, and made one hundred and fifty-six days to the close of the Exhibition. The locomotive 'Delaware,' Class 8-18 D (eight-wheeled, six wheels coupled three feet diameter, cylinders twelve by sixteen, weight thirty-nine thousand pounds), came into service June 9,

and made one hundred and thirty-one days to the close of the Exhibition. The usual load of each engine was five eight-wheeled passenger cars, frequently carrying over one hundred passengers per car. On special occasions as many as six and seven loaded cars have been drawn by one of these engines.

"Each engine averaged fully sixteen trips daily, equal to fifty-six miles, and, as the stations were but a short distance apart, the Westinghouse air-brake was applied in making one hundred and sixty daily stops, or a total of twenty-five thousand for each engine. Neither engine was out of service an hour unless from accidents for which they were in no way responsible."

[NOTE.—Average weight of each loaded car about twelve gross tons.]

The year 1876 was also marked by an extension of locomotive engineering to a new field in the practice of these works. In the latter part of the previous year an experimental steam street-car was constructed for the purpose of testing the applicability of steam to street railways. This car was completed in November, 1875, and was tried for a few days on a street railway in Philadelphia. It was then sent to Brooklyn, December 25, 1875, where it ran from that time until June, 1876. One engineer ran the car and kept it in working order. Its consumption of fuel was between seven and eight pounds of coal per mile run. It drew regularly, night and morning, an additional car, with passengers going into New York in the morning, and returning at night. On several occasions, where speed was practicable, the car was run at the rate of sixteen to eighteen miles per hour.

In June, 1876, this car was withdrawn from the Atlantic Avenue Railway of Brooklyn, and placed on the Market Street Railway of Philadelphia. It worked with fair success, and very acceptably to the public on that line, from June till nearly the close of the Centennial Exhibition.

This original steam-car was built with cylinders under the body of the car, the connecting-rods taking hold of a crank-axle, to which the front wheels were attached. The rear wheels of the car were independent, and not coupled with the front wheels. The machinery of the car was attached to an iron bed-plate bolted directly to the wooden framework of the car body. The experiment with this car demonstrated to the satisfaction of its builders the mechanical practicability of the use of steam on street railways, but the defects developed by this experimental

car were: first, that it was difficult, or impossible, to make a crank-axle which would not break, the same experience being reached in this respect which had already presented itself in locomotive construction; second, it was found that great objection existed to attaching the machinery to the wooden car body, which was not sufficiently rigid for the purpose, and which suffered by being racked and strained by the working of the machinery.

For these reasons this original steam-car was reconstructed, in accordance with the experience which nearly a year's service had suggested. The machinery was made "outside-connected," the same as an ordinary locomotive, and a strong iron framework was designed, entirely independent of the car body, and suporting the boiler and all the machinery.

STEAM STREET-CAR.

The car as thus reconstructed was named the "Baldwin," and is shown by the above illustration.

The next step in this direction was the construction of a separate "motor," to which one or more cars could be attached. Such a machine, weighing about sixteen thousand pounds, was constructed in the fall of 1876, and sent to the Citizens' Railway of Baltimore, which has the maximum grades of seven feet per hundred, or three hundred and sixty-nine and six-tenths feet per mile. It ascended the three hundred and sixty-nine feet grade, drawing one loaded car, when the tracks were covered with mixed snow and dirt to a depth of eight to

ten inches in places. Another and smaller motor, weighing only thirteen thousand pounds, was constructed about the same time for the Urbano Railway, of Havana, Cuba. Orders for other similar machines followed, and during the ensuing years 1877-78-79-80 one hundred and seven separate motors and

STEAM MOTOR FOR STREET-CARS.

twelve steam-cars were included in the product. Various city and suburban railways have been constructed with the especial view of employing steam-power, and have been equipped with these machines. One line, the Hill & West Dubuque Street Railway, of Dubuque, Iowa, was constructed early in 1877, of three and a half feet gauge, with a maximum gradient of nine in one hundred, and was worked exclusively by two of these motors. The details and character of construction of these machines are essentially the same as locomotive work, but they are made so as to be substantially noiseless, and to show little or no smoke and steam in operation.

Steel fire-boxes with vertical corrugations in the side sheets were first made by these works early in 1876, in locomotives for the Central Railroad of New Jersey, and for the Delaware, Lackawanna and Western Railway.

The first American locomotives for New South Wales and Queensland were constructed by the Baldwin Locomotive Works in 1877, and have since been succeeded by additional orders. Six locomotives of the "Consolidation" type for three and one-half feet gauge were also constructed in the latter year for the Government Railways of New Zealand, and two freight locomotives, six-wheels-connected with forward truck, for the Government of Victoria. Four similar locomotives (ten-wheeled,

six-coupled, with sixteen by twenty-four cylinders) were also built during the same year for the Norwegian State Railways.

Forty heavy "Mogul" locomotives (nineteen by twenty-four cylinders, driving-wheels four and one-half feet in diameter) were constructed early in 1878 for two Russian Railways (the Koursk Charkof Azof, and the Orel Griazi). The definite order for these locomotives was only received on the sixteenth of December, 1877, and, as all were required to be delivered in Russia by the following May, especial despatch was necessary. The working force was increased from eleven hundred to twenty-three hundred men in about two weeks. The first of the forty engines was erected and tried under steam on January 5th, three weeks after receipt of order, and was finished, ready to dismantle and pack for shipment, one week later. The last engine of this order was completed February 13th. The forty engines were thus constructed in about eight weeks, besides twenty-eight additional engines on other orders, which were constructed wholly or partially, and shipped during the same period.

The production during the years from 1872 to 1899 inclusive was as follows:

1872	422	locomotives.	
1873	437	"	
1874	205	"	
1875	130	"	
1876	232	"	
1877	185	"	
1878	292	"	
1879	298	"	
1880	517	"	
1881	554	"	
1882	563	"	(6,000th locomotive completed.)
1883	557	"	(7,000th locomotive completed.)
1884	429	"	
1885	242	"	
1886	550	"	(8,000th locomotive completed.)
1887	653	"	
1888	737	"	(9,000th locomotive completed.)
1889	827	"	
1890	946	"	(11,000th locomotive completed.)

1891......899	locomotives.	(12,000th locomotive completed.)
1892......731	"	(13,000th locomotive completed.)
1893......772	"	
1894......313	"	(14,000th locomotive completed.)
1895......401	"	
1896......547	"	(15,000th locomotive completed.)
1897......501	"	
1898......755	"	(16,000th locomotive completed.)
1899......901	"	(17,000th locomotive completed.)

Four tramway motors of twelve tons weight were built early in 1879, on the order of the New South Wales Government, for a tramway having grades of six per cent., and running from the railway terminus to the Sydney Exhibition Grounds. Subsequently orders have followed for additional motors for other tramways in Sydney.

The five thousandth locomotive, finished in April, 1880, presented some novel features. It was designed for fast passenger service on the Bound Brook line between Philadelphia and New York, and to run with a light train at a speed of sixty miles per hour, using anthracite coal as fuel. It had cylinders eighteen by twenty-four, one pair of driving-wheels six and one-half feet in diameter, and a pair of trailing-wheels forty-five inches in diameter, and equalized with the driving-wheels. Back of the driving-wheels and over the trailing-wheels space was given for a wide fire-box (eight feet long by seven feet wide inside) as required for anthracite coal. By an auxiliary steam cylinder placed under the waist of the boiler, just in front of the fire-box, the bearings on the equalizing beams between trailing- and driving-wheels could be changed to a point forward of their normal position, so as to increase the weight on the driving-wheels when required. The adhesion could thus be varied between the limits of thirty-five thousand to forty-five thousand pounds on the single pair of driving-wheels. This feature of the locomotive was made the subject of a patent.

In 1881, a compressed-air locomotive was constructed for the Pneumatic Tramway Engine Company, of New York, on plans prepared by Mr. Robert Hardie. Air-tanks of steel, one-half inch thick, with a capacity of four hundred and sixty-five cubic

feet were combined with an upright cylindrical heater, thirty-two and five-eighths inches in diameter. The weight of the machine was thirty-five thousand pounds, of which twenty-eight thousand pounds were on four driving-wheels, forty-two inches in diameter. The cylinders were twelve and a half inches diameter by eighteen inches stroke. Another novelty of the year was a steam-car to take the place of a hand-car. Accompanying illustration shows the design. Its cylinders were four by ten inches, and wheels twenty-four inches diameter. Built for standard gauge track, its weight in working order was five thousand one hundred and ten pounds. Similar cars have since been constructed. During this year the largest single order ever placed on the books was entered for the Mexican National Construction Company. It was for one hundred and fifty locomotives, but only a portion of them were ever built.

STEAM INSPECTION CAR.

The year 1882 was marked by a demand for locomotives greater than could be met by the capacity of existing locomotive works. Orders for one thousand three hundred and twenty-one locomotives were entered on the books during the year, deliveries of the greater part being promised only in the following year. The six-thousandth locomotive was completed in January of this year, and the seven-thousandth in October, 1883.

Early in 1882 an inquiry was received from the Brazilian Government for locomotives for the Cantagallo Railway, which were required to meet the following conditions: To haul a train of forty gross tons of cars and lading up a grade of eight and three-tenths per cent. (four hundred and thirty-eight feet per mile), occurring in combination with curves of forty metres radius (one hundred and thirty-one feet radius, or forty-three and eight-tenths degrees). The line is laid with heavy steel rails, and the gauge is one and one-tenth metres, or three feet seven and one-third inches. The track upon which it was proposed to run

these locomotives is a constant succession of reverse curves, it being stated that ninety-one curves of the radius named occur within a distance of three thousand four hundred and twenty-nine metres, or about two miles. The line had previously been operated on the "Fell" system, with central rack rail, and it was proposed to introduce locomotives working by ordinary adhesion, utilizing the central rail for the application of brake power. An order was eventually received to proceed with the construction of three locomotives to do this work. The engines built were of the following general dimensions, viz.: Cylinders, eighteen by twenty inches; six driving-wheels connected, thirty-nine inches in diameter; wheel-base, nine feet six inches; boiler, fifty-four inches in diameter, with one hundred and ninety flues two inches diameter, ten feet nine inches long; and with side tanks, carried on the locomotive. In March, 1883, they were shipped from Philadelphia, and on a trial made October 17, in the presence of the officials of the road and other prominent railway officers, the guaranteed performance was accomplished. One of the engines pulled a train weighing forty tons, composed of three freight cars loaded with sleepers and one passenger car, and made the first distance of eight kilometres to Boca do Mato with a speed of twenty-four kilometres per hour; from there it started, making easily an acclivity of eight and five-tenths per cent. in grade, and against a curve of forty metres in radius. Eight additional locomotives for this line were constructed at intervals during the following ten years, and the road has been worked by locomotives with ordinary adhesion since their adoption as above described.

In 1885 a locomotive was built for the Dom Pedro Segundo Railway of Brazil, having five pairs of driving-wheels connected and a leading two-wheeled truck. From this has arisen the title "Decapod" (having ten feet) as applied to subsequent locomotives of this type. Its cylinders were twenty-two by twenty-six inches; driving-wheels forty-five inches diameter and grouped in a driving-wheel-base of seventeen feet. The rear flanged driving-wheels, however, were given one- quarter of an inch more total play on the rails than the next adjacent pair; the second and third pairs were without flanges, and the front pair was

flanged. The locomotive could therefore pass a curve of a radius as short as five hundred feet, the rails being spread one- half inch wider than the gauge of track, as is usual on curves. The flanges of the first and fourth pairs of driving-wheels, making practically a rigid wheel-base of twelve feet eight inches, determined the friction on a curve. The weight of the engine in workingorder was one hundred and forty-one thousand pounds, of which one hundred and twenty-six thousand pounds were on the driving-wheels. During this year the first rack-rail locomotive in the practice of these Works was constructed for the Ferro Principe do Grão Pará Railroad of Brazil. Its general dimensions were: Cylinders, twelve by twenty inches; pitch line of cog-wheel, 41.35 inches; weight, 15.74 tons. Several additional similar locomotives, but of different weights, have since been constructed for the same line.

At the close of this year, Mr. Edward Longstreth withdrew from the firm on account of ill health, and a new partnership was formed, adding Messrs. William C. Stroud, William H. Morrow, and William L. Austin. Mr. Stroud had been connected with the business since 1867, first as bookkeeper and subsequently as Financial Manager. Mr. Morrow, since entering the service in 1871, had acquired a varied and valuable experience, first in the accounts, then in the department of extra work, and subsequently

LOCOMOTIVE WITH OUTSIDE FRAMES.

as Assistant Superintendent, becoming General Manager on Mr. Longstreth's retirement. Mr. Austin, who entered the works in 1870, had for several years been assistant to Mr. Henszey in all matters connected with the designing of locomotives. The eight-thousandth locomotive was completed in June, 1886. A loco-

motive for the Antofogasta Railway (thirty inches gauge) of Chili, constructed with outside frames, was completed in November, 1886, and is illustrated on page 77. The advantages of this method of construction of narrow-gauge locomotives in certain cases were evidenced in the working of this machine, in giving a greater width of fire-box between the frames and a greater stability of the engine due to the outside journal bearings.

In 1887 a new form of boiler was brought out in some ten-wheeled locomotives constructed for the Denver and Rio Grande Railroad. A long wagon-top was used, extending sufficiently forward of the crown-sheet to allow the dome to be placed in front of the fire-box and near the centre of the boiler, and the crown-sheet was supported by radial stays from the outside shell. Many boilers of this type have since been constructed.

Mr. Charles T. Parry, who had been connected with the Works almost from their beginning and a partner since 1867, died on July 18, 1887, after an illness of several months.

The first locomotives for Japan were shipped in June, 1887, being two six-wheeled engines of three feet six inch gauge for the Mie Kie mines.

Mr. William H. Morrow, a partner since January 1, 1886, and who had been previously associated with the business since 1871, died February 19, 1888.

RACK LOCOMOTIVE, RIGGENBACH SYSTEM.

The demand for steam motors for street railway service attained large proportions at this period, and ninety-five were built during the years 1888 and 1889. Two rack-rail locomotives on the Riggenbach system, one with a single cog-wheel and four carrying-wheels, and weighing in working order thirty-two thousand pounds, for the Corcovado Railway of Brazil, and the other having two cog-wheels and eight carrying-wheels and weighing in working order seventy-nine thousand pounds, for the Estrada de Ferro Principe do Grão Pará of

Brazil, were constructed during this year. The general plans are shown by accompanying illustrations.

In October, 1889, the first compound locomotive in the practice of the Works was completed and placed on the Baltimore and Ohio Railroad. It was of the four-cylinder type, as designed and patented by Mr. S. M. Vauclain, who had been connected with the works since 1883 and its General Superintendent since February 11, 1886. The economy in fuel and water and the efficiency in both passenger and freight service given by this design led to its introduction on many leading railroads. Following the first four-cylinder compound locomotives built in 1889, three were built in 1890, eighty-two in 1891, two hundred and thirteen in 1892, one hundred and sixty in 1893, thirty in 1894, fifty-one in 1895, one hundred and seventy-three during 1896, eighty-six in 1897, two hundred and thirty-five in 1898, two hundred and forty-one in 1899.


RACK LOCOMOTIVE, WITH TWO COG-WHEELS.

In 1889 a test case was made to see in how short a time a locomotive could be built. On Saturday, June 22, Mr. Robert H. Coleman ordered a narrow-gauge "American" type passenger locomotive and tender, which it was agreed should be ready for service on his railroad in Lebanon County, Pa., by the fourth of July following. The boiler material was at once ordered and was received Tuesday, June 25. The boiler was completed and taken to the Erecting Shop on Friday, June 28, and on Monday, July 1, the machinery, frames, wheels, etc., were attached and the locomotive was tried under steam in the works. The tender was completed the following day, Tuesday, July 2, thus making the record of construction of a complete locomotive from the raw material of the art in eight working days.

The manufacture of wrought iron wheel-centres for both truck and driving-wheels was begun at this time under patents of Mr. S. M. Vauclain, Nos. 462,605, 462,606, and 531,487.

In 1890 the first rack-rail locomotive on the Abt system was constructed for the Pike's Peak Railroad, and during this year

and 1893 four locomotives were built for working the grades of that line, which vary from eight to twenty-five per cent. One of these locomotives, weighing in working order fifty-two thousand six hundred and eighty pounds, pushes twenty-five thousand pounds up the maximum grades of one in four. An illustration is here given of one of these locomotives, which is a four-cylinder "Compound."

RACK LOCOMOTIVE, ABT SYSTEM.

Three "Mogul" locomotives, of one metre gauge, fifteen by eighteen cylinders, driving-wheels forty-one inches diameter, were completed and shipped in July, 1890, for working the Jaffa and Jerusalem Railway in Palestine, and two additional locomotives for the same line were constructed in 1892.

In 1891 the largest locomotives in the practice of the works were designed and constructed. For the St. Clair Tunnel of the Grand Trunk Railway, under the St. Clair River, four tank locomotives were supplied, each with cylinders twenty-two by twenty-eight; five pairs of driving-wheels connected, fifty inches diameter, in a wheel-base of eighteen feet five inches; boiler, seventy-four inches diameter; fire-box, eleven feet long by three and one-half feet wide; and tanks on the boiler of twenty-one hundred and ten gallons capacity. The weight in working order of each engine was one hundred and eighty-six thousand eight hundred pounds without fire in fire-box. The tunnel is six thousand feet long, with grades of two per cent. at each entrance, twenty-five hundred and nineteen hundred and fifty feet long respectively. Each locomotive was required to take a train load of seven hundred and sixty tons exclusive of its own

"DECAPOD."

weight, and in actual operation each of these locomotives has hauled from twenty-five to thirty-three loaded cars in one train through the tunnel.

For the New York, Lake Erie and Western Railroad, five Compound locomotives of the "Decapod" class were completed in December, 1891. Their general dimensions were as follows: Cylinders, high pressure sixteen inches, low pressure twenty-seven inches diameter, stroke twenty-eight inches; five pairs of driving-wheels coupled fifty inches diameter in a wheel-base of eighteen feet ten inches; boiler seventy-six inches diameter; three hundred and fifty-four tubes, two inches diameter, twelve feet long; fire-box (Wootten type) eleven feet long, eight feet two inches wide inside; combustion chamber thirty-six inches long; weight in working order one hundred and ninety-five thousand pounds, weight on driving-wheels one hundred and seventy-two thousand pounds; weight of eight-wheeled tender with fuel and four thousand five hundred gallons of water, eighty-nine thousand four hundred and twenty pounds. The first, fourth, and fifth pairs of driving-wheels were flanged, but the fifth pair had one-fourth inch additional play on the track. These locomotives are used as pushers on the Susquehanna Hill, where curves of five degrees are combined with grades of sixty feet per mile, doing the work of two ordinary "Consolidation" locomotives. From one thousand two hundred and fifty to one thousand three hundred net tons of cars and lading, making a train of forty-five loaded cars, are hauled by one of these locomotives in connection with a twenty by twenty-four cylinder "Consolidation."

S. Ellero-Saltino (Vallombrosa).

Mr. William C. Stroud, who had been a partner since 1886, died on September 21, 1891.

The first locomotives for Africa were constructed during this year. They were of the "Mogul" type, with cylinders eighteen by twenty-two inches, driving-wheels forty-eight inches diameter, and for three feet six inches gauge.

The product for 1892 and 1893 included, as novelties, two rack-rail locomotives for a mountain railway near Florence, Italy, and twenty-five compound "Forney" locomotives for the South Side Elevated Railroad, of Chicago. At the World's Columbian Exposition in Chicago, May to October inclusive, an exhibit was made consisting of seventeen locomotives, as follows:

STANDARD GAUGE.—A Decapod locomotive, similar to those above described, built in 1891 for the New York, Lake Erie and Western Railroad. A high-speed locomotive of new type, with Vauclain compound cylinders, a two-wheel leading truck, two pairs of driving-wheels, and a pair of trailing wheels under the fire-box. This locomotive was named "Columbia," and the same name has been applied to the type. An express passenger locomotive of the pattern used by the Central Railroad of New Jersey; one of the pattern used by the Philadelphia and Reading Railroad, and one of the pattern used by the Baltimore and Ohio Railroad. The three roads mentioned operate together the "Royal Blue Line" between New York and Washington. A saddle tank double-ender type locomotive, with steam windlass, illustrating typical logging locomotive practice. A single expansion 18x24 cylinder American type locomotive. A single expansion 19x24 cylinder Mogul locomotive. A single expansion 20x24 cylinder ten-wheel freight locomotive for the Baltimore and Ohio Southwestern Railroad. A compound ten-wheel passenger locomotive shown in connection with a train exhibited by the Pullman Palace Car Company. A compound Consolidation locomotive for the Norfolk and Western Railroad. Three locomotives were shown in connection with the special exhibit of the Baltimore and Ohio Railroad, viz., one compound, one single expansion, and one ten-wheel passenger locomotive.

NARROW-GAUGE.—A one-metre-gauge compound American type locomotive; a three-foot-gauge ten-wheel compound locomotive, with outside frames, for the Mexican National Railroad; and a thirty-inch-gauge saddle tank locomotive for mill or furnace work.

The depression of business which began in the summer of 1893, reduced the output of the works for that year to seven hundred and seventy-two, and in 1894 to three hundred and

thirteen locomotives. Early in 1895, a new type of passenger locomotive was brought out, illustrated by annexed cut. To this the name "Atlantic" type was given. The advantages found in this design are a large boiler, fitting the engine for high speed;

"ATLANTIC" TYPE.

a fire-box of liberal proportions and a desirable form placed over the rear frames, but of ample depth and width; and the location of the driving-wheels in front of the fire-box, allowing the boiler to be placed lower than in the ordinary "American" or "Ten-wheeled" type. For the enginemen, who, in this class of locomotive, ride behind, instead of over the driving-wheels, greater ease in riding, and greater safety in case of the breakage of a side-rod, are important advantages.

The first electric locomotive was constructed in 1895, and was intended for experimental work for account of the North American Company. The electrical parts were designed by Messrs. Sprague, Duncan & Hutchison, Electrical Engineers, New York. Two other electric locomotives for use in connection with mining operations were built in 1896, in co-operation with the Westinghouse Electric Manufacturing Company, which supplied the electrical parts.

ELECTRIC LOCOMOTIVE.

A high-speed passenger locomotive, embracing several novel features, was built in 1895, for service on the New York division of the Philadelphia and Reading Railroad. The boiler was of

the Wootten type, the cylinders were compound, thirteen and twenty-two by twenty-six, and the driving-wheels (one pair) were eighty-four and one-quarter inches diameter. The cut below shows the general design.

HIGH-SPEED LOCOMOTIVE.

The weight of the engine in working order was as follows: On front truck, thirty-nine thousand pounds; on trailing wheels, twenty-eight thousand pounds; on the driving-wheels, forty-eight thousand pounds. This locomotive and a duplicate built in the following year have been regularly used in passenger service, hauling from five to eight cars, and making the distance between Jersey City and Philadelphia, ninety miles, in one hundred and five minutes, including six stops.

In July, 1895, a combination rack and adhesion locomotive was constructed for the San Domingo Improvement Company, having compound cylinders eight inches and thirteen inches diameter by eighteen inches stroke to operate two pairs of coupled adhesion wheels, and a pair of single expansion cylinders, eleven inches by eighteen inches, to operate a single rack-wheel constructed upon the Abt system.

COMBINATION RACK AND ADHESION LOCOMOTIVE.

This locomotive was furnished with two complete sets of machinery, entirely independent of each other, and was built with the view eventually to remove the rack attachments and operate the locomotive by adhesion alone.

During the years 1895 and 1896 contracts were executed for several railroads in Russia, aggregating one hundred and thirty-eight locomotives of the four-cylinder compound type.

On January 1, 1896, Samuel M. Vauclain, Alba B. Johnson, and George Burnham, Jr., were admitted to partnership.

Two combination rack and adhesion locomotives were built in 1896 for the Peñoles Mining Company, of Mexico, having compound cylinders nine and one-half and fifteen inches diameter by twenty-two inches stroke, connected to the driving-wheels through walking-beams. Two pairs of wheels are secured to the axles by clutches and act as adhesion driving-wheels, and the rear wheels are loose on the axle and act only as carrying wheels. All three coupled axles carry rack pinions of the Abt system. The two pairs of adhesion wheels are thrown into operation by means of the clutches.

COMBINATION RACK AND ADHESION LOCOMOTIVE.

In the latter part of the year 1896, six locomotives were built for the Baltimore and Ohio Railroad, for express passenger service. One of these locomotives, No. 1312, is here illustrated. They are the "Ten-wheel" type, with cylinders twenty-one by twenty-six inches, driving wheels seventy-eight inches diameter, and weigh in working order about one hundred and forty-five thousand pounds, about one hundred and

TEN-WHEEL LOCOMOTIVE.
For Baltimore and Ohio R. R.

thirteen thousand pounds of which is on the driving wheels. These locomotives have handled the fast passenger trains on the Baltimore and Ohio Railroad running between Philadelphia, Baltimore and Washington with great efficiency.

In the summer of 1897, the Reading Railway placed a fast train on its Atlantic City Division, allowing fifty-two minutes for running time from Camden to Atlantic City, a distance of fifty-five and one-half miles, making the average rate of speed sixty-four miles per hour. The trains averaged five and six

Atlantic Type Locomotive.
For Phila. and Reading Ry.

cars, having a total weight of about two hundred tons, not including the engine and tender. This train is hauled by locomotive No. 1027 of the Atlantic type, having Vauclain compound cylinders, thirteen and twenty-two inches in diameter by twenty-six inches stroke, with driving-wheels eighty-four and one-quarter inches, and weighing in working order on driving-wheels seventy-eight thousand six-hundred pounds, the total weight of engine and tender complete being two hundred and twenty-seven thousand pounds. The records show that for fifty-two days from July 2nd to August 31, 1897, the average time consumed on the run was forty-eight minutes, equivalent to a uniform rate of speed from start to stop of sixty-nine miles per hour. On one occasion the distance was covered in forty-six and one-half minutes, an average of

Consolidation Locomotive
For Lehigh Valley R. R.

seventy-one and six-tenths miles per hour. The same train was continued in service during the season of 1898 and 1899 with equal results.

In November, 1898, a locomotive was built for the Lehigh Valley Railroad for use on the mountain cut-off between Coxton and Fairview, near Wilkesbarre.

This locomotive is of the Consolidation type, with Vauclain compound cylinders, and of the general dimensions following: Cylinders, eighteen and thirty inches diameter, thirty inches stroke, driving-wheels, fifty-five inches outside diameter; boiler, Wootten type, eighty inches diameter at smallest ring, with a total heating surface of four thousand one hundred and five square feet; weight in working order, on drivers, two hundred and two thousand two hundred and thirty-two pounds; weight, total engine, two hundred and twenty-six thousand pounds. Tank capacity, seven thousand gallons.

ATLANTIC TYPE LOCOMOTIVE.
For Chicago, Burlington and Quincy R. R.

Weight of engine and tender about three hundred and forty-six thousand pounds. This locomotive was guaranteed to haul a load of one thousand net tons, exclusive of the weight of the engine and tender, on a grade of sixty-six feet per mile at an average speed of seventeen miles per hour. It fulfilled this guarantee and fourteen similar locomotives were subsequently ordered by this Company.

In March, 1899, two locomotives were built for the Chicago, Burlington & Quincy Railroad, for the fast mail service west of Chicago. These were of the "Atlantic" type with Vauclain compound cylinders, thirteen and one-half and twenty-three inches in diameter and twenty-six inches stroke, driving-wheels eighty-four and one-quarter inches in diameter, weight in working order eighty-five thousand eight hundred and fifty pounds on driving-wheels, and one hundred and fifty-nine thousand pounds total of engine. The total weight of engine

and tender complete is about two hundred and fifty-four thousand pounds.

Dr. Edward H. Williams, who had been connected with the Works as a partner since 1870, died December 21, 1899, at Santa Barbara, California.

The year 1899 was marked by a large increase in foreign business, notably in England and France. Contracts were made in England covering thirty locomotives for the Midland Railway, twenty locomotives for the Great Northern Railway, and twenty locomotives for the Great Central Railway. Ten locomotives were also ordered by the French State Railways, and ten by the Bone Guelma Railway, in the French colonies of Algiers.

The record of the Baldwin Locomotive Works has thus been given for sixty-eight years of existence and continuous operation. Over seventeen thousand locomotives have been constructed since the "Old Ironsides," in 1831. That engine was nearly a year in building.

The following figures indicate the growth of the Works:

Works established			1831
1,000th	locomotive	built	1861
2,000th	"	"	1869
3,000th	"	"	1872
4,000th	"	"	1876
5,000th	"	"	1880
6,000th	"	"	1882
7,000th	"	"	1883
8,000th	"	"	1886
9,000th	"	"	1888
10,000th	"	"	1889
11,000th	"	"	1890
12,000th	"	"	1891
13,000th	"	"	1892
14,000th	"	"	1894
15,000th	"	"	1896
16,000th	"	"	1898
17,000th	"	"	1899

It will be seen from the foregoing that, while thirty years were occupied in building the first thousand engines, almost as many were built in the single year of 1890.

The present organization, based upon an annual capacity of one thousand locomotives, equal to three and one-third locomotives per working day, is as follows:

Number of men employed	8,000
Hours of labor per man per day	10
Principal departments run continuously, hours per day	23
Horse-power employed	6,000
Number of buildings comprised in Works	29
Acreage comprised in works	16
Number of dynamos for furnishing power,	8
H.-P.	1,600
Number of dynamos for lighting	6 Arc 4 Incandescent
Number of electric lamps in service	3,000 Incandescent 300 Arc
Horse-power of electric motors employed for power transmission, aggregate H.-P.	3,000
Consumption of coal, in net tons, per week, approximately	1,200
Consumption of iron, in net tons, per week, approximately	2,000
Consumption of other materials, in net tons per day, approximately	100

The location, in the largest manufacturing city in America, gives especial facilities and advantages. Proximity to the principal coal and iron regions of the country renders all required materials promptly available. A large permanent population of skilled mechanics, employed in similar branches in other Philadelphia workshops, gives an abundant force of expert workmen from which to draw when necessary. All parts of locomotives and tenders, except the boiler and tank plates, the steel tires, and steel castings, chilled wheels, boiler tubes and special patented appliances, are made in the Works from the raw materials.

PREFACE TO CATALOGUE.

THE following pages present and illustrate a system of **Narrow-Gauge Locomotives,** in which it is believed will be found suitable designs for all ordinary requirements of service.

These patterns admit of modifications to suit the preferences of railroad managers, and where locomotives of peculiar construction for special service are required, designs will be prepared and submitted or locomotives built to specifications furnished.

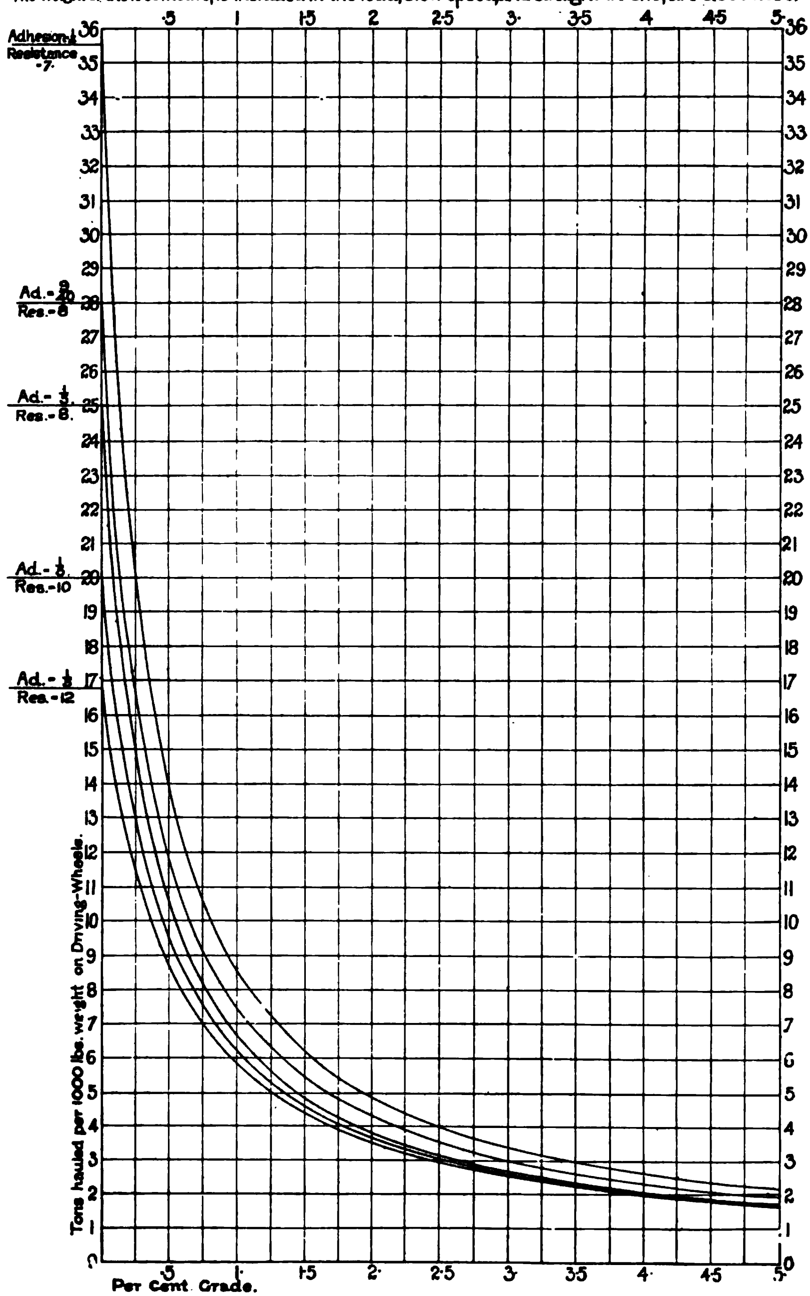
The locomotives of the system herewith presented are adapted to the consumption as fuel of wood, coke, or bituminous coal.

By the system of manufacture employed, all important parts are accurately made to gauges and templates; they are therefore interchangeable throughout any number of locomotives of the same class. This system permits of any parts needed for repairs being supplied either with the locomotive or whenever subsequently required. Such parts are made to the same gauges and templates which were originally used in the construction of the locomotive, and in this manner the expense of repairs is reduced to a minimum and the maintenance of locomotive power is attended with the least possible inconvenience and delay. It is only necessary to give the construction number of the locomotive and describe the part which is required, and it can be furnished from the works at the shortest notice, guaranteed to fit in place.

Particulars are given of the hauling capacity of the various classes illustrated, based upon actual work done. The basis of these calculations is a factor of adhesion of nine-fortieths (or say .225) of the weight on driving-wheels, whilst the maximum mean effective pressure on pistons at slow speed is taken at eighty per cent. of the nominal boiler pressure. It is assumed that the frictional resistance of the cars hauled will not exceed eight pounds per ton of 2240 pounds. These conditions are taken as those prevailing under ordinarily favorable conditions, with track and cars in good order, and exclusive of the resistance of curves. Allowance may be made for curvature by considering each degree of curvature as equivalent to the resistance of straight grade, at the rate of one and one-half feet rise per mile. One

Hauling Capacity in Tons (of 2240 lbs) for each 1000 lbs. on Driving Wheels

The weight of the locomotive, is included in the load, slow speed, and straight tracks, are assumed



degree of curvature is 5730 feet radius. Therefore the actual radius divided into 5730 gives the number of degrees of any curve.

The diagram on page 91 shows graphically the number of tons (of 2240 pounds) which should be hauled on grades from level to 4.5 per cent., at slow speed, by any locomotive, inclusive of the weight of the engine and tender, for each 1,000 pounds weight on driving-wheels. The weight of engine and tender, in tons of 2240 pounds, must be deducted to get the weight of cars and lading. Five bases of calculation are shown by separate lines in this diagram. Under the most favorable conditions, such as well-surfaced track, dry rails, well lubricated rolling-stock, etc., adhesion equal to one-fourth or ten-fortieths of the weight on driving-wheels may be developed; but as these conditions cannot at all times be realized, the loads given in the folowing tables are based on the second line, or nine-fortieths the weight on driving-wheels. Even this basis, which may be considered as representing average excellent conditions, is more favorable than frequently prevails on narrow-gauge lines having light rails or poorly laid track, logging railroads, etc. The other three lines are added to the diagram to make provision for such cases. The selection of the basis of calculation must of course be made in each instance with reference to the actual or probable condition of the road and its rolling equipment.

Designs and estimates for any sizes or patterns of locomotives not given in this catalogue will be submitted on application. The delivery of locomotives at any point which can be reached by rail or vessel will be included in contracts if desired.

In ordering locomotives the following particulars should be given:

1. Gauge of track,—exact distance between the rails.
2. Kind of fuel which will be used.
3. Kind and height of couplings of cars.
4. Limitations, if any, in height and width, by tunnels, overhead bridges, etc.
5. Mark, name, or number.

The A B C Code (Fourth Edition, 1881), the A 1 Code, Lieber's Code, the Vanguard Code or Baldwin Locomotive Works' private code may be employed in telegraphing.

GENERAL SPECIFICATIONS.

THE materials used in the construction of locomotives conform to the physical and chemical requirements given below. All purchases are made upon the basis of these specifications, and the conformity of all materials therewith is carefully verified in a well-equipped testing laboratory. Likewise numerous tests are made daily of the cast iron and other materials manufactured in the Works. Complete records are kept for each locomotive, and in the event of accident or litigation accurate testimony can be furnished.

PHYSICAL TESTS OF MATERIALS.

All materials shall be of the best quality of their respective kinds, carefully inspected, and subjected to the following tests. Notwithstanding these tests, should any defects be developed in working, the corresponding part will be rejected.

Boiler and Fire Box Steel. All plates must be rolled from steel manufactured by the open hearth process, and must conform to the following chemical analysis:

	BOILER STEEL.	FURNACE STEEL.
Carbon, between . .	0.15 and 0.25 per cent.	0.15 and 0.25 per cent.
Phosphorus, not over	0.05 per cent.	0.03 per cent.
Manganese, not over	0.45 "	0.45 "
Silicon, not over . .	0.03 "	0.03 "
Sulphur, not over .	0.05 "	0.035 "

No sheets will be accepted that show mechanical defects. A test strip taken lengthwise from each sheet rolled and without annealing should have a tensile strength of 60,000 pounds per square inch, and an elongation of 25 per cent., in section originally 8 inches long. Sheets will not be accepted if the test show a tensile strength less than 55,000 pounds, or greater than 65,000 pounds, per square inch, nor if the elongation fall below 20 per cent.

Boiler Iron. All boiler iron plates are to be of C. H. No. 1 Flange quality, and to be made from best charcoal iron blooms. A careful examination will be made of every plate, and none will be accepted that show mechanical defects.

All boiler iron to be C. H. No. 1 Flange quality, and must be made from the best charcoal blooms, and must be free from mechanical defects. Should any plates develop defects in working, they will be rejected.

A test piece to be furnished from each sheet, which must show an ultimate tensile strength with the grain of not less than 50,000 pounds, an ultimate tensile strength across the grain of not less than 45,000 pounds, and must show an elongation of not less than 20 per cent. A drifting test will be made of at least two pieces. No plates will be accepted which will not permit of a 1¼″ hole being drifted out cold to 3″ diameter. Each plate must be stamped with the maker's name and the guaranteed tensile strength and elongation as above.

Fire Box Copper. Copper plates for fire boxes must be rolled from best quality Lake Superior ingots; they must have a tensile strength of not less than 30,000 pounds per square inch, and an elongation of at least 20 per cent., in section originally 2 inches long. Test strips must be furnished with each fire box for testing.

Stay Bolt Iron. Iron for stay bolts must be double refined, and show an ultimate tensile strength of at least 48,000 pounds per square inch, with a minimum elongation of 25 per cent., in a test section 8 inches long. Pieces 24 inches long must stand bending double, both ways, without showing fracture or flaw. Iron must be rolled true to gauges furnished, and permit of cutting a clean, sharp thread.

Copper Stay Bolts. Copper stay bolts must be manufactured from the best Lake Superior ingots; they must have an ultimate tensile strength of not less than 30,000 pounds per square inch, and an elongation of at least 20 per cent., in section originally 2 inches long.

Boiler Tubes of Charcoal Iron. All boiler tubes must be carefully inspected and be free from pit-holes or other imperfections. Each tube must be subjected by the manufacturers, before delivery, to an internal hydraulic pressure of not less than 500 pounds per square inch. They must be rolled accurately to the gauge furnished by the Baldwin Locomotive Works, filling the gauge to a plump fit. They must be expanded in the boiler without crack or flaw.

A test section 1¼ inches long, cut from any tube, must permit

of vertical hammering without showing transverse cracks when flattened down.

Boiler Tubes of Brass or Copper, Brass and Copper Pipes. Tubes of brass or copper to be of uniform circumferential thickness and solid drawn ; to be perfectly round and to resist an internal hydraulic pressure of 300 pounds per square inch. From the tubes under test a piece 4 inches long will be cut, annealed, sawed lengthwise, and doubled inside out without showing sign of cracks.

When annealed they must withstand flanging cold, without cracking, a flange 5/8 of an inch broad for 2-inch tubes. Copper tubes must withstand flanging hot as well as cold. Tubes other sizes than 2 inches diameter must flange to a width proportional to their diameter.

A piece 30 inches long, annealed, and filled with rosin, must withstand being doubled until the extremities touch each other without showing defects.

A piece 30 inches long, not annealed, filled with rosin, and placed on supports 20 inches apart, must withstand bending to a deflection of 3 inches without showing defects.

Bar Iron. Bar iron should have a tensile strength of 50,000 pounds per square inch, and an elongation of 20 per cent., in section originally 2 inches long. Iron will not be accepted if tensile strength falls below 48,000 pounds, nor if elongation is less than 15 per cent., nor if it shows a granular fracture.

Steel Tank Plates. Tank plates to be rolled from homogeneous steel billets, and must be of good finish, free from surface defects, such as spalling or bad buckling. The steel to be of such quality that pieces taken lengthwise of any plate selected shall show no sign of fracture when bent double cold over a mandril whose diameter is one and a half times thickness of plate so tested.

Steel for Forgings. All blooms for use in axles, pins, rods, guides, and similar forgings, must be made by the open-hearth process, and be free from seams, slivers, and other surface defects. No chipping will be permitted for the removal of such defects.

Drillings will be taken from a point midway between the center and the surface of the bloom, and must conform to the following specifications when analyzed by Baldwin Locomotive Works standard methods :

Carbon	0.37 to 0.40
Manganese, not over	0.60
Phosphorous	0.05
Sulphur, about	0.05

These blooms should be of such quality that a test-piece machined cold from a full-sized bloom of each heat used in filling our orders should, when tested, have an ultimate tensile strength of 80,000 pounds per square inch, and an elongation of 20 per cent., in a test section originally 2 inches long.

Blooms will not be accepted that show an ultimate tensile strength of less than 75,000 or more than 90,000 pounds per square inch, or an elongation of less than 15 per cent.

All forgings which develop seams or pipes upon machining will be returned, and must be replaced by new blooms at the expense of the manufacturer.

Chilled Wheels. Of approved make, and of following guaranteed mileage:

For 28″ wheels	40,000 miles.
" 30″ "	45,000 "
" 33″ "	50,000 "

Other sizes in proportion.

(Adopted by Joint Committee of Master Car Builders' Association, American Railway Master Mechanics' Association, and Association of Manufacturers of Chilled Car Wheels, November 21, 1889.)

Deficient mileage will be adjusted upon return of the defective wheel, or that part of same containing the defect causing withdrawal from service. Or, if preferred, wheels will be furnished subject to approved specification and drop test, without mileage guarantee.

Spring Steel. All spring steel must be manufactured by the crucible process, and must be free from any physical defects. The metal desired has the following composition:

Carbon	1.00 per cent.
Manganese	0.25 "
Phosphorous, not over	0.03 "
Silicon, not over	0.15 "
Sulphur, not over	0.03 "
Copper, not over	0.03 "

Steel will not be accepted which shows on analysis less than 0.90 or over 1.10 per cent. of carbon, or over 0.50 per cent. of manganese, 0.05 per cent. of Phosphorus, 0.25 per cent. of silicon, 0.05 per cent. of sulphur, and 0.05 per cent. of copper.

Phosphor Bronze. All bronze to be made from new metals, and should show the following analysis:

Copper	79.70 per cent.
Tin	10.00 "
Lead	9.50 "
Phosphorus	0.80 "

Bronze will be rejected should analysis show results outside the following limits:

Tin	below	9.00 per cent.	or over	11.00 per cent.
Lead	"	8.00 "	"	11.00 "
Phosphorus	"	0.70 "	"	1.00 "

Bronze will also be rejected in case it contains 0.50 per cent. of any other substances than the four elements mentioned in this specification.

Steel Tires. All tires to be made of dense, homogeneous bottom-poured ingots, and to insure freedom from pipes, segregations and other imperfections, the steel must be cast in long, hexagonal ingots, and not less than 20 per cent. of the weight of the ingot must be discarded from the top portion.

Tires supported in running position on an anvil weighing at least 10 tons, and subjected to repeated blows of a tup weighing 2,240 pounds, must show a minimum deflection of $\frac{1}{8}$ the internal diameter for all tires exceeding 36″ internal diameter, of $\frac{1}{10}$ the internal diameter for all tires exceeding 24″ internal diameter and not more than 36″, and of $\frac{1}{14}$ the internal diameter for all tires less than 24″ internal diameter.

A test piece cut cold from tire must show a tensile strength of 108,000 to 120,000 pounds per square inch, and a reduction of area of 15 per cent. The elongation measured in a 2″ section to be not less than 12 per cent. for the minimum tensile strength.

Tires will be rejected if the following maximum limits are exceeded:

Manganese	.75 per cent.
Phosphorus	.05 per cent.
Sulphur	.05 per cent.

BALDWIN LOCOMOTIVE WORKS.

BURNHAM, WILLIAMS & CO.

PHILADELPHIA..

Class............................] [Drawing No ....

SPECIFICATION.

No.......................

Of a.. Locomotive Engine, having.............. ..pairs of coupled wheels and a..................wheeled................. truck ; for the..Company. (This specification may be referred to in cabling by code word... . ....)

Design. General design illustrated by attached photograph of engine ....

Dimensions. CYLINDERS. High-pressure cylinders..................inches diameter and................ inches stroke.

Low-pressure cylinders...............inches diameter and....................... inches stroke.

DRIVING WHEELS....................inches diameter. GAUGE.......... .. . . feet..................inches. FUEL ....

Wheelbase. Total wheelbase...... feet...... ... inches. Driving wheelbase..................feet ....inches.

Total wheelbase of locomotive and tender not to exceed............... feet..................inches.

Weight. In working order, total about.................lbs.; on driving-wheels, about.. .. ..lbs.

WEIGHT of tender, with fuel and water, about.............................. pounds.

Limits. Of height.............. feet..................inches; of width .. .. feet...................inches.

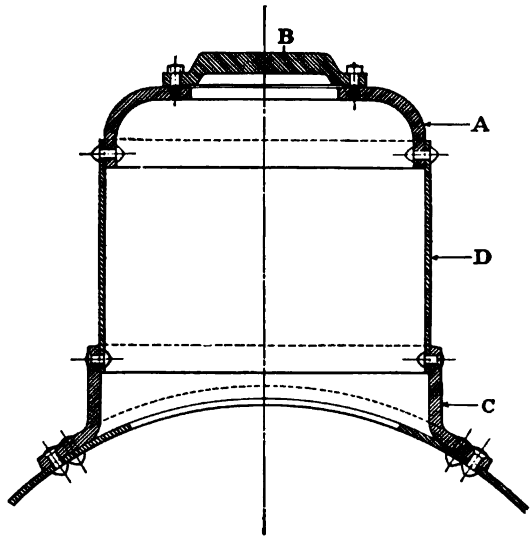
Boiler. Made of plates of homogeneous steel for a working pressure of...... .. ..pounds per square inch, and tested with steam to at least 20 pounds per square inch above working pressure, and with hot water to one-third above the working pressure. Waist .... inches in diameter at smoke-box end; made........................ top, with one dome placed.. Waist plates..............................inch thick; all longitudinal seams................ ....

....

All boiler and fire-box seams calked inside and outside where possible. All holes reamed perfectly true after sheets are put together, holes slightly countersunk on inside and outside edges. No hand riveting permitted except where it is impossible to use power riveters. Throat sheet of sufficient thickness to prevent undue thinning where flanged. All parts well and thoroughly stayed. Liners on inside of side sheets, providing double thickness of metal for studs of expansion braces, if side-sheets are less than nine-sixteenths of an inch thick. All calking edges of plates planed where possible and calked with round-pointed calking tool, insuring plates against injury by chipping in calking with sharp-edged tools. All boiler brace jaws drop forged, with holes drilled. All rivet and pinholes in braces to be drilled. All jaw pins to be turned to give full body bearing on both sides of jaw, and to be held in position by nut, washer and cotter-pin. All T-irons fastened to the interior of boiler-shell to be machined accurately to fit the radius of boiler. Tube sheets to be thoroughly annealed and tube holes accurately reamed to gauges. Sharp corners carefully rounded to avoid cutting tubes in setting.

Dome. Dome Ring (A) to be of seamless open hearth forged steel, turned and accurately fitted to the interior of dome sheet

before being drilled and riveted. Dome Cap (B) to be of forged steel. Dome Base (C) to be of seamless open hearth forged steel, flanged and radially planed to fit the outer shell of boiler. The interior bored to receive the body sheet of dome. All rivets connecting dome to boiler to be driven by hydraulic pressure. The body sheet of the dome (D) to be seamless open-hearth steel, fitted over dome ring by shrinkage.



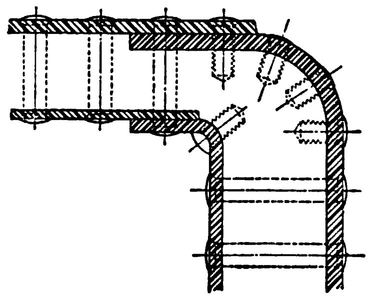
DOME.

Tubes. Of..
No.................wire gauge, with copper ferrules on swaged ends in fire box tube-sheet..............in number..............inches in diameter, and..............feet..............inches in length.

Fire-box. ....inches long and ....inches wide inside; of homogeneous steel, all flanged plates thoroughly annealed after flanging; side and back sheets, ...inch thick. Crown sheet ....inch thick; flue sheet, one-half inch thick. Water space..............inches sides and back,..............inches front. Outside and inside surfaces of water-space frame, against which the sheets of the fire box and outer shell are riveted, to be machined smooth and fitted to gauges. Corners to be machined to fit lap of sheets, no scarfing of sheet at joint permitted. Rivets through water-space frame countersunk both inside and outside, in order that the shrinking of the

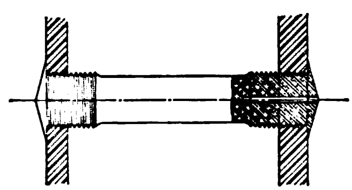
rivets shall tighten the sheet rather than have a tendency to pull off the head. The vertical seams at the throat and back sheets to have countersunk rivets both inside and outside, to allow full width of water space and to admit of removal of boiler without dismantling frames. Stay bolts of iron.................................. inch diameter, screwed and riveted to sheet, and not over four and one-half inches from centre to centre. All stay-bolts to have three-sixteenths-inch hole, one and one-quarter inches deep from outside, to indicate when broken in service. All stay-bolts threads turned off between sheets. Fire-door opening formed by flanging and riveting together the inner and outer sheets. Tool guard to be cast on lower part of fire-door frame. Fire-brick arch...

....



WATER-SPACE CORNERS.

Crown Staying. CROWN SHEET supported by Crown bars, each made of two pieces of wrought iron..............................inches by ....inches, set one and one-half inches above crown, placed not over four and one-half inches from centre to centre, and bearing on side sheets. Crown bar bolts not over four and one-half inches from centre to centre, with head on under side of crown-sheet. Crown-bars stayed by braces to outside shell of boiler, or



STAY-BOLT

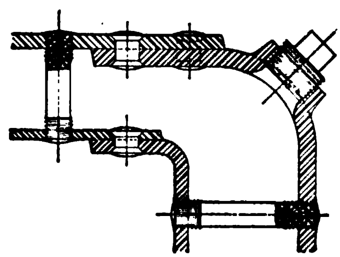
By ⊥-bars,.........................inches by.........................inches, placed not less than three inches above crown and not over eight inches apart from centre to centre, bolts with taper fit through crown sheet and not over four and one-half inches from centre to centre. ⊥-bars supported by wrought iron thimbles and stayed by braces to outside shell of boiler, or

By Radial Stay-bolts......................inches diameter, not over four and one-half inches from centre to centre, screwed through crown sheet and roof of boiler, and riveted over. Front end of crown sheet to be supported by sling stays.

Steam Pipes. Dry steam pipe inside boiler of wrought iron. Steam pipes in smoke box of cast iron.

Cleaning Holes. Cleaning plugs located where necessary for proper cleaning of boilers.

Corner wash-out holes when placed diagonally, to be re-inforced by flanging sheet out-ward and tapping interior of flange to receive plug.



WASH-OUT PLUG AND RIVETS IN WATER-LEG SEAMS.

Throttle Valve. Balanced puppet throttle valve of cast iron, in vertical arm of dry-pipe.

Grates, etc. GRATES..................................ASH-PAN....................................

Smoke Stack. ....

Smoke Box. Extended, with netting, deflecting plate, and spark ejector or spark hopper.

Frames. Of hammered iron or cast steel, made in two sections.

Front rails bolted and keyed to main frames, and with front and back lugs forged on for cylinder connections.

Pedestals. Pedestals in one piece with main frames and protected from wear of boxes by cast iron gibs and wedges. Pedestal cap lugged and bolted to bottom of pedestals.

Engine-Truck. Centre-bearing swivelling..................wheeled truck ....

Frame. Truck frame of wrought iron, with braces of wrought iron; fitted with swinging bolster or with fixed centre-bearing.

Wheels. .... wheels, ...inches diameter.

Axles. Of hammered steel with journals.................. inches in diameter and...................inches long.

Springs. Of crucible cast steel tempered in oil, connected by equalizing beams resting on top of boxes.

Cylinders. Of close-grained iron as hard as can be worked; each cylinder cast in one piece with half-saddle, and placed horizontally; right- and left-hand cylinders reversible and interchangeable; accurately planed, fitted, and bolted together in the most approved manner. Valve face and steam chest seat raised above face of cylinder to allow for wear, except when piston valves are used. Cylinders oiled by automatic sight feed lubricator placed in cab, and connected to steam chests by copper pipes running under jacket. Pipes proved to 300 pounds pressure.

Pistons. PISTONS of cast iron, fitted with approved form of steam packing. PISTON-RODS of iron or steel, ground and keyed to cross-heads, and securely fastened to pistons.

Packing. Metallic packing for piston rod and valve-stems.

Guides. Of steel, cast iron, or wrought iron case hardened, fitted to wrought iron guide-yoke.

Cross Heads. Of..with suitable bearings

....

Valve Motion. Shifting link motion, graduated to cut off equally at all points of stroke. Links, sliding-blocks, pins, lifting links, and eccentric rod jaws made of hammered iron, well case hardened. Sliding blocks with long flanges to give ample wearing surface. Rock shafts of wrought iron; reverse shaft of wrought iron. Slide valves..

Driving Wheels. ....in number;...................inches in diameter. Centres of cast.................turned to..............................inches diameter.

....

Tires. Of cast steel.....................inches thick when finished;.................... pairs flanged.....................inches wide; ....pairs plain ....inches wide.

Axles. Of hammered steel; journals.....................inches diameter and ....inches long. DRIVING-BOXES of cast iron, with brass bearings.

Springs. Of crucible cast steel, tempered in oil. EQUALIZING BEAMS of wrought iron or cast steel.

Rods. CONNECTING and PARALLEL RODS of hammered steel. Connecting rods forged solid, and furnished with all necessary straps, keys and brasses. Parallel rods with straps, keys, and brasses or with solid ends and heavy brass bushings. Bushings put in by hydraulic press, and well secured from turning in rod.

Oil-Cups. Lubrication of all bearings carefully provided for, and oil-cups attached where required. Wick, plunger or adjustable needle oil-cups on rods and guides.

Wrist Pins. WRIST-PINS of steel.

Feed Water. Supplied by...injectors.

Cab. Substantially built of clear, sound ash, or clear pine, well finished, and fitted together with joint bolts and corner plates. To be provided with suitable windows and doors, conveniently arranged, and glazed with first quality double American crystal glass. Cab seats, cab seat cushion and an engineer's arm rest to be provided.

Pilot. Of wood braced with iron...

Furniture. Engine to be furnished with..................................sand-box ...., sander, bell and bell cord, one extra fusible plug, engineer's torch.

BOILER FITTINGS: Whistle, blow-off cock, blower valve, safety valves, steam gauge with lamp, and gauge cocks.

TOOLS: Two heavy jack screws and levers, one heavy pinch bar with steel point and heel, complete set of wrenches to fit all nuts and bolts on engine, two monkey wrenches, one set of driving-box packing tools, one machinist's hammer, one soft hammer and three cold chisels (two flat and one cape).

CANS: One long spout quart oil can, one two gallon oil can, and one tallow pot.

FIRING IRONS: One poker, one scraper, one slice bar, and one scoop shovel.

Headlight. ....

Brake. ....

....

Couplers. ....

Finish. Boiler lagged with.., neatly jacketed, and secured by iron bands. Dome lagged with same material as boiler, with painted iron casing on body and cast iron top and bottom rings. Cylinders lagged with same material as boiler, and neatly cased with iron, painted. Cylinder head covers of hydraulic forged steel, painted or polished. Steam chests with cast iron tops; bodies cased with iron, painted, except where piston valves are used. Hand rails of............................. Running boards of wood with nosings of angle iron.

Painting. Engine and tender to be well painted and varnished. Lettering and numbering to be painted as specified by purchaser.

Gauges. All principal parts of engine accurately fitted to gauges and templates, and thoroughly interchangeable.

Case Hardening. All finished movable nuts and all wearing surfaces of valve motion made of steel, or iron case hardened.

Alloy. All wearing brasses made of phosphor bronze or ingot copper and tin, alloyed in proportion to give best mixture for wearing bearings.

Threads. All threads on bolts to be United States standard.

TENDER.

Tank. Tank of steel strongly put together, with angle-iron corners and well braced. Top, inside, and bottom plates......................thick; outside plates......................thick; riveted with.............................inch rivets, ...inches pitch. Capacity........................ gallons (of 231 cubic inches).
Shape of tank..

Frame. Tender frame substantially built of...................................., strongly braced.

Trucks. Two four-wheeled centre-bearing trucks; made with wrought iron side bars and cross beams of wood or channel iron; additional bearings at sides of back truck. Springs, crucible cast steel, tempered in oil.

Wheels..................inches diameter. Brakes on all wheels.

AXLES of hammered steel; outside journals..................inches diameter and..................inches long. Oil tight boxes with brass bearings.

Tool Boxes. Tool-boxes of hard wood, fitted with locks and keys.

CLASS DESIGNATIONS.

THE different classes of locomotives illustrated in this catalogue are designated by a combination of figures with one of the letters C, D, or E, to indicate both the plan and size, as follows:

The letter C indicates that four wheels are connected as driving-wheels.

The letter D indicates that six wheels are connected as driving-wheels.

The letter E indicates that eight wheels are connected as driving-wheels.

A figure (4, 6, 8, 10, or 12) is used as an initial figure, to indicate the whole number of wheels under the locomotive.

A figure or figures, following the initial figure, indicates the diameter of the cylinders, viz.:

8 indicates cylinders 7 inches in diameter.

10½ indicates cylinders 8 inches in diameter.

11 indicates cylinders 9 inches in diameter with stroke not exceeding 14 inches.

12 indicates cylinders 9 inches in diameter with stroke exceeding 14 inches.

14 indicates cylinders 10″ dia.	34 indicates cylinders 20″ dia.
16 indicates cylinders 11″ dia.	36 indicates cylinders 21″ dia.
18 indicates cylinders 12″ dia.	38 indicates cylinders 22″ dia.
20 indicates cylinders 13″ dia.	40 indicates cylinders 23″ dia.
22 indicates cylinders 14″ dia.	42 indicates cylinders 24″ dia.
24 indicates cylinders 15″ dia.	44 indicates cylinders 25″ dia.
26 indicates cylinders 16″ dia.	46 indicates cylinders 26″ dia.
28 indicates cylinders 17″ dia.	48 indicates cylinders 27″ dia.
30 indicates cylinders 18″ dia.	50 indicates cylinders 28″ dia.
32 indicates cylinders 19″ dia.	

Thus, 8-24 C indicates a locomotive with eight wheels in all, having four wheels coupled, and cylinders fifteen inches in diam-

eter; 8-24 D indicates a locomotive with eight wheels in all, having six wheels coupled, and cylinders of the same diameter; and 10-34 E indicates a locomotive with ten wheels in all, having eight wheels coupled, and cylinders twenty inches in diameter.

The same rule applies to Baldwin four-cylinder compound locomotives (Vauclain system). Thus, 10-$\frac{22}{42}$ **D** indicates a locomotive with ten wheels in all, having six wheels coupled, a fourteen-inch high-pressure cylinder on each side, and a twenty-four-inch low-pressure cylinder on each side.

The addition of the fraction ¼ indicates that there is a truck placed at each end of the locomotive. Thus, 8-24¼ C indicates a locomotive with eight wheels in all, having four wheels coupled, cylinders fifteen inches in diameter, and a two-wheeled truck at each end.

The addition of the fraction ⅓ indicates that the front truck is omitted and a rear truck is placed back of the fire-box. Thus, 8-24 ⅓ D indicates a locomotive with eight wheels in all, having six wheels coupled, cylinders fifteen inches in diameter, and a two-wheeled rear truck.

From the above system of classification, and omitting the figures indicating the cylinder diameter for particular sizes, the following type designations are deduced:

4	C Tank.	Two pairs of coupled wheels, with saddle or side tanks, no trucks.
4	C Tender.	Two pairs of coupled wheels, with separate tender, no trucks.
6	C Tank.	Two pairs of coupled wheels and two-wheeled front truck, with saddle or side tanks.
6	C Tender.	Two pairs of coupled wheels and two-wheeled front truck, with separate tender.
6⅓	C Tank.	Two pairs of coupled wheels and two-wheeled back truck, with saddle, side, or rear tanks.
8	C Tender.	American type. Two pairs of coupled wheels, four-wheeled front truck, and separate tender.
8¼	C Tank.	Two pairs of coupled wheels, with two-wheeled truck front, and two-wheeled truck back, with saddle or side tanks.

8¼	C Tender.	Columbia type. Two pairs of coupled wheels, two-wheeled front truck, and one pair of trailing wheels under fire box, with separate tender.
8⅓	C Tank.	Two pairs of coupled wheels, with four-wheeled back-truck, supporting tank at back end.
10¼	C Tender.	Atlantic type. Two pairs of coupled wheels, four-wheeled front truck, and one pair of trailing wheels under fire-box, with separate tender.
6	D Tank.	Three pairs of coupled wheels, with saddle or side tanks, no trucks.
6	D Tender.	Three pairs of coupled wheels, with separate tender, no trucks.
8	D Tender.	Mogul type. Three pairs of coupled wheels, two-wheeled front truck, and separate tender.
8⅓	D Tank.	Three pairs of coupled wheels and two-wheeled back truck, with saddle, side, or rear tanks.
10	D Tender.	Three pairs of coupled wheels, four-wheeled front truck, and separate tender.
10¼	D Tank.	Three pairs of coupled wheels, two-wheeled front and two-wheeled back truck, with saddle or side tanks.
10	E Tender.	Consolidation type. Four pairs of coupled wheels, two-wheeled front truck, and separate tender.
12¼	E Tank.	Four pairs of coupled wheels, two-wheeled front and two-wheeled back truck with saddle or side tanks.

The figures following the class designation, as found on every locomotive, give the class number for that locomotive, and supply an individual designation for it, in addition to the construction number. Thus, 8-26 C 500 means the five-hundredth locomotive of the 8-26 C class.

Cuts of these, and other types, more fully illustrating this system of classification, are shown on pages 240 to 252.

"AMERICAN" TYPE LOCOMOTIVES.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF FOUR SIZES OF THIS PATTERN.

Series 908. Code Word, "Lutricole"

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tender for Water, 8⅓-Pound Gallons.	Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.							CODE WORD.
									On a Grade per Mile of						
			Total.	Of Driving-Wheels.		Total.	On all Driving-Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	
8–18 C	12 x 18 or 20	48 to 56	21′ 1″	7′ 6″	1800	49,000	32,000	825	325	190	130	90	70	55	Lutrin
8–20 C	13 x 18 or 20	48 to 56	21′ 9″	7′ 10″	2000	57,000	37,000	975	390	230	155	110	85	65	Luttasses
8–22 C	14 x 18 or 20	48 to 56	22′ 1″	8′ 2″	2200	64,000	42,000	1120	445	260	175	130	95	75	Lutteriez
8–24 C	15 x 18 or 20	48 to 56	22′ 5″	8′ 6″	2400	72,000	48,000	1280	510	300	205	150	115	85	Lutterons

This type is suitable for passenger, freight, or mixed service, where the run is of such length as to require a separate tender, or for short lines intended ultimately to be extended. It is called the "American" type because of its almost universal use for many years throughout the United States for nearly every variety of service. Heavier locomotives of the "American" type are included in Series 917, page 112.

The total wheel-base of engine, with six-wheeled tender attached, varies from 37 feet 2 inches for class 8–18 C, to 38 feet 6 inches for class 8–24 C. From 18 inches to 2 feet should be added to give the length of turn-table required.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 8–18 C and 8–20 C can be used on rails of 35 to 40 pounds per yard, and classes 8–22 C and 8–24 C, 45 to 50 pounds.

For remarks on tractive power, see pages 90 to 92.

$\frac{9}{40}$ & 8 T x 20

"AMERICAN" TYPE LOCOMOTIVE (DEEP FIRE-BOX)

"AMERICAN" TYPE LOCOMOTIVES.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF THREE SIZES OF THIS PATTERN.

Series 917. Code Word, "Lutteur"

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tender for Water, 8⅓ pound Gallons.	Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.							CODE WORD.
									On a Grade per Mile of						
			Total.	Of Driving-Wheels.		Total.	On all Driving Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	
8–22 C	14 x 20 or 22	54	18′ 2″	6′ 0″	2200	64,000	44,000	1150	470	275	190	135	105	80	Luttons
8–24 C	15 x 22 or 24	60	19′ 6″	6′ 6″	2400	72,000	50,000	1320	535	315	215	160	120	95	Luttuoso
8–26 C	16 x 22 or 24	60	20′ 4″	7′ 0″	2600	80,000	56,000	1475	600	355	240	175	135	105	Lutulencia

The locomotives of Series 908 have deep fire-boxes between the driving axles, placed over depressed slab frames. In the larger classes of eight-wheel or "American" type locomotives the grate area which can be thus obtained is limited by the spread of driving-wheels practicable. To obtain increased grate area the fire-box is extended back over the rear driving-axle, and the frames are, therefore, depressed only at the front of the fire-box to give sufficient depth under the tubes. In this construction it is practicable and desirable to shorten the spread of driving-wheels. This form of fire-box is suitable for burning coal, but the deeper fire-boxes of Series 908 are preferable for wood-burning locomotives.

Assuming that steel rails, properly supported by cross ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, class 8-22 C can be used on rails of 50 pounds per yard, class 8-24 C, 55 pounds, and class 8-26 C, 60 pounds.

For remarks on tractive power, see pages 90 to 92.

"AMERICAN" TYPE LOCOMOTIVE (INCLINED FIRE-BOX).

"ATLANTIC" TYPE LOCOMOTIVES.

TWO PAIRS OF DRIVING-WHEELS, TWO TRAILING-WHEELS AND FOUR-WHEELED LEADING TRUCK.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF THREE SIZES OF THIS PATTERN.

Series 907. Code Word, "Lutulent."

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.			Capacity of Tender for Water, 8⅓-Pound Gallons.	Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.							CODE WORD.
									On a Level.	On a Grade per Mile of						
			Total.	Rigid.	Driving.		Total.	On all Driving-Wheels.		26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	
10-22¼ C	14 x 20	50	18′ 2″	9′ 2″	4′ 7″	2600	72,000	42,000	1100	435	255	170	120	90	70	Lutulentas
10-24¼ C	15 x 22	54	19′ 4″	10′ 0″	5′ 0″	2800	82,000	50,000	1300	525	310	210	150	115	85	Luurgoed
10-26¼ C	16 x 22	54	19′ 4″	10′ 0″	5′ 0″	3000	90,000	56,000	1475	585	345	230	165	125	95	Luurkorf

Locomotives of this plan are especially adapted to high speed service. The driving-wheels are placed forward of the fire-box, allowing the use of a boiler of large heating surface, with a deep fire box placed over the frames, and giving a low centre of gravity with large driving-wheels. Excessive weight per axle is obviated by the introduction of a pair of trailing wheels at the rear, under the overhanging fire box. The driving-wheels are coupled closely together, affording a short parallel rod, which is an important consideration in high speed service, at the same time giving ample length of main rod. The coupled and trailing-wheels are equalized together, giving the locomotive a smooth and easy motion when running at high speed.

The total wheel-base of engine, with eight-wheeled tender attached, varies from 41 feet 6 inches for class 10-22¼ C, to 43 feet for class 10-26¼ C. From 18 inches to 2 feet should be added to give length of turn-table desired.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, class 10-22¼ C can be used on rails of 45 pounds per yard, class 10-24¼ C 50 pounds, and 10-26¼ C 60 pounds.

For remarks on tractive power, see pages 90 to 92.

$\frac{9}{10}$ & 8, T. x 20.

"ATLANTIC" TYPE LOCOMOTIVE.

"MOGUL" TYPE LOCOMOTIVES.

SIX-WHEELED-CONNECTED, WITH PONY TRUCK AND SEPARATE TENDER, FOR FREIGHT, OR MIXED SERVICE.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF TWELVE SIZES OF THIS PATTERN.

Series 911. Code Word, "Luurkorven"

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tender for Water, 8⅓ pound Gallons.	Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.							CODE WORD.
									On a Grade per Mile of						
			Total.	Of Driving-Wheels.		Total.	On all Driving Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	
8–14 D	10 x 16	38	14′ 1″	8′ 0″	1400	30,000	24,000	675	255	150	100	75	55	45	Luurmand
8–16 D	11 x 16	38	14′ 5″	8′ 4″	1600	36,000	30,000	775	320	190	130	95	75	55	Luurmanden
8–18 D	12 x 18	42	15′ 2″	9′ 0″	1800	44,000	36,000	950	390	230	160	115	90	70	Luveiro
8–20 D	13 x 18	42	16′ 0″	9′ 8″	2000	51,000	42,000	1100	450	270	185	135	105	85	Luvetto
8–22 D	14 x 18	42	16′ 3″	9′ 8″	2200	57,000	48,000	1275	520	310	215	155	120	95	Luvhalter
8–24 D	15 x 18	42	18′ 0″	10′ 9″	2400	66,000	56,000	1500	605	365	250	185	145	115	Luvseite
8–26 D	16 x 18	42	18′ 6″	11′ 3″	2600	72,000	62,000	1650	675	405	280	205	160	130	Luvwaerts
8–26 D	16 x 20	48	18′ 6″	11′ 3″	2600	74,000	64,000	1700	695	415	290	215	165	135	Luwer
8–28 D	17 x 20	42	18′ 11″	11′ 6″	2800	81,000	70,000	1875	760	455	315	235	185	145	Luxabimus
8–28 D	17 x 22	48	18′ 11″	11′ 6″	2800	83,000	72,000	1975	805	485	335	250	195	155	Luxacao
8–30 D	18 x 20	42	19′ 8″	12′ 0″	3000	90,000	78,000	2100	850	510	355	265	205	165	Luxaciones
8–30 D	18 x 22	48	19′ 8″	12′ 0″	3000	92,000	80,000	2200	895	535	370	275	215	175	Luxada

Locomotives of this type are suitable for passenger, freight, or mixed service, where the eight-wheeled, or "American" type, would not afford sufficient power, or where the requisite weight on the driving-wheels, if carried by only two pairs, would be greater than the rails could safely bear.

The front and back driving-wheels must have flanged tires in this type of locomotive; the middle or main driving-wheels have wide tires without flanges. The "pony truck" has a swinging bolster, and by means of a radius bar is made to radiate about a point located between itself and the front driving-axle.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 8-14 D to 8-20 D can be used on rails of 20 to 30 pounds per yard; classes 8-22 D and 8-24 D, 35 to 40 pounds; classes 8-26 D and 8-28 D, 45 to 50 pounds; class 8-30 D, 60 pounds.

For remarks on tractive power, see pages 90 to 92.

"MOGUL" TYPE LOCOMOTIVE.

"TEN-WHEELED" TYPE LOCOMOTIVES.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF TEN SIZES OF THIS PATTERN.

Series 913. Code Word, "Luxandi."

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tender for Water, 8⅓-Pound Gallons.	Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.							CODE WORD.
								On a Level.	On a Grade per Mile of						
			Total.	Of Driving-Wheels.		Total.	On all Driving-Wheels.		26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet or 1½ per cent.	105.6 Feet or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	
10-18 D	12 x 18	42	17′ 7″	9′ 0″	1800	48,000	36,000	950	385	230	155	115	85	70	Luxaremus
10-20 D	13 x 18	42	18′ 5″	9′ 8″	2000	55,000	42,000	1100	450	265	185	135	105	80	Luxation
10-22 D	14 x 18	42	18′ 8″	9′ 8″	2200	62,000	48,000	1275	515	305	210	155	120	95	Luxationem
10-24 D	15 x 18	42	19′ 10″	10′ 9″	2400	71,000	56,000	1500	605	360	250	185	140	110	Luxationis
10-26 D	16 x 18	42	20′ 4″	11′ 0″	2600	78,000	62,000	1650	670	400	275	205	160	125	Luxaveras
10-26 D	16 x 20	48	20′ 4″	11′ 0″	2600	80,000	64,000	1700	690	410	285	210	165	130	Luxaverint
10-28 D	17 x 20	42	21′ 3″	11′ 6″	2800	87,000	70,000	1875	760	455	315	230	180	145	Luxavit
10-28 D	17 x 22	48	21′ 3″	11′ 6″	2800	93,000	76,000	2000	825	495	345	255	200	160	Luxero
10-30 D	18 x 20	42	21′ 9″	12′ 0″	3000	100,000	82,000	2200	890	535	370	275	215	170	Luxissent
10-30 D	18 x 22	48	21′ 9″	12′ 0″	3000	104,000	86,000	2300	940	565	390	290	225	180	Luxistis

This type is suitable for passenger, freight, or mixed service, where a locomotive of the "American" type would not afford sufficient power, or where the requisite weight, if carried on only two pairs of driving-wheels, would be greater than the rails could safely bear. The greater length of an engine of this plan admits of a longer boiler, and, consequently, greater heating surface.

If the curves are of short radius, the front and rear driving-wheels are, preferably, flanged, and the truck made with swing bolster. For lines of easy curvature the middle and rear driving-wheels may be flanged and the truck made with rigid centre.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 10-18 D to 10-22 D can be used on rails of 25 to 35 pounds per yard; and classes 10-24 D and 10-26 D, 40 to 45 pounds; and classes 10-28 D and 10-30 D, 50 to 60 pounds.

For remarks on tractive power, see pages 90 to 92.

$\frac{9}{10}$ & 8, T x 20.

"TEN-WHEELED" TYPE LOCOMOTIVE.

"CONSOLIDATION" TYPE LOCOMOTIVES

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF SEVEN SIZES OF THIS PATTERN.

Series 914 Code Word, "Luxorum."

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tender for Water, 8⅓-Pound Gallons.	Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.							CODE WORD.
									On a Grade per Mile of						
			Total.	Of Driving-Wheels.		Total.	On all Driving-Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	
10-24 E	15 x 18	38	17′ 8″	11′ 3″	2400	67,000	58,000	1550	635	385	270	185	150	115	Luxueux
10-24½ E	15 x 20	38	18′ 6″	11′10″	2500	73,000	64,000	1700	705	425	295	220	175	140	Luxuliane
10-26 E	16 x 20	42	18′11″	12′ 3″	2600	79,000	70,000	1875	765	460	320	240	185	150	Luxuria
10-28 E	17 x 20	42	20′ 1″	13′ 3″	2800	87,000	76,000	2025	825	500	350	260	205	165	Luxuriabit
10-30 E	18 x 20	42	20′ 9″	13′11″	3000	96,000	83,000	2215	910	545	380	285	225	180	Luxuriamus
10-32 E	19 x 22	48	21′ 6″	14′ 0″	3200	104,000	90,000	2425	990	595	415	310	245	195	Luxuriance
10-34 E	20 x 22	48	21′ 6″	14′ 0″	3400	112,000	98,000	2625	1075	650	455	340	265	215	Luxuriant

Where adequate adhesion cannot be obtained by the use of a locomotive having only three pairs of driving-wheels, without overloading the rails, a locomotive of the "Consolidation" type, as described above, having the adhesive weight distributed over four pairs of driving-wheels, may be employed, to afford the maximum power. In this type of locomotive the front and back pairs of driving-wheels have flanged tires, the intermediate pairs have tires without flanges. The pony truck has a swinging bolster and radius bar.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 10–24 E and 10–24½ E can be used on rails of 30 to 35 pounds per yard; classes 10-26 E to 10-30 E, 40 to 50 pounds; classes 10-32 E and 10 34 E, 50 to 55 pounds. If practicable, however, it is desirable to have rails heavy enough to give a greater factor of strength.

Any of the locomotives described above, with six-wheeled tenders attached, except classes 10-32 E and 10-34 E, can be constructed to turn on 40 feet turn-tables. Classes 10-32 E and 10-34 E, would require turn-tables 43 feet 6 inches and 45 feet long respectively.

For remarks on tractive power, see pages 90 to 92.

9/10 & 8, T. x 20.

"CONSOLIDATION" TYPE LOCOMOTIVE

FOUR-COUPLED TANK LOCOMOTIVES.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

FOR ALL KINDS OF SWITCHING AND SPECIAL SERVICE IN MILLS, MINES, FURNACES, PLANTATIONS, ETC.

PRINCIPAL DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF ELEVEN SIZES OF THIS PATTERN.

Series 900. Code Word, "Luxuriatum."

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.	Capacity of Tank for Water, 8⅓-Pound Gallons.	Weight in Working Order. Pounds.	LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING. On a Level.	On a Grade per Mile of 26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	CODE WORD
4-6 C	6 x 12	24	3′ 10″	110	12,000	275	120	75	50	40	30	25	Luxuriavis
4-8 C	7 x 12	26	3′ 10″	150	14,000	350	145	90	60	45	35	30	Luxuries
4-10½ C	8 x 12	28	4′ 0″	200	17,000	430	180	110	75	60	45	35	Luxurieux
4-11 C	9 x 14	30	4′ 0″	300	21,000	500	215	130	90	70	55	45	Luxuriosis
4 12 C	9 x 16	33	5′ 0″	350	28,000	650	270	165	115	90	70	60	Luxurioso
4 14 C	10 x 16	33	5′ 0″	400	31,000	775	325	200	140	105	85	70	Luxurists
4-16 C	11 x 16	33 to 38	5′ 6″	450	36,000	850	350	220	155	120	95	75	Luxury
4-18 C	12 x 16	33 to 38	5′ 6″	500	40,000	980	415	255	180	135	110	90	Luxus
4-20 C	13 x 18	38 to 42	6′ 0″	550	47,000	1175	495	300	215	165	130	105	Luytosa
4-22 C	14 x 18	38 to 42	6′ 6″	600	54,000	1375	575	350	250	190	155	125	Luzbel
4-24 C	15 x 20	42 to 48	7′ 0″	700	62,000	1500	640	390	275	210	170	140	Luzeiro

The weight given in each case is for the locomotive in working order with the tank full of water, but includes no fuel. The latter may be offset against the reduction of weight as the water is drawn from the tank. The figures given may therefore be considered as the *average* weight in running order.

This type of locomotive is the simplest for service on short lines, where a sufficient supply of fuel and water can be carried on the engine. All the weight, being on the driving-wheels, is utilized for adhesion, and the maximum load consistent with the weight of the engine can be drawn. Having but two pairs of wheels allows of a wheel-base short enough to pass the sharpest curves without difficulty. Engines of this type can be run equally well in either direction.

Assuming that steel rails, properly supported by cross ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 4-6 C and 4-8 C can be used on rails of 12 to 16 pounds per yard; classes 4-10½ C and 4-11 C, 20 to 25 pounds; classes 4-12 C to 4-16 C, 30 to 40 pounds; classes 4-18 C and 4-20 C, 45 to 60 pounds. If practicable, however, it is desirable to have rails heavy enough to give a greater factor of strength.

For remarks on tractive power, see pages 90 to 92.

9/10 & 8, ½ T. C.

FOUR-COUPLED TANK LOCOMOTIVE.

TANK LOCOMOTIVES.

WITH TWO PAIRS OF DRIVING-WHEELS AND TWO-WHEELED REAR TRUCK.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF NINE SIZES OF THIS PATTERN.

Series 903. Code Word, "Luzeluze"

Class	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base. Total.	Wheel-Base. Of Driving-Wheels.	Capacity of Tank for Water, 8⅓-Pound Gallons. Tank on Boiler.	Weight in Working Order. Pounds. Total.	Weight in Working Order. Pounds. On all Driving-Wheels.	Load in Tons (of 2240 pounds), of Cars and Lading. On a Level.	On a Grade per Mile of 26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet or 1½ per cent.	105.6 Feet or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	Code Word.
6-10⅓ C	8 x 12	28	9′ 7″	3′ 9″	300	23,000	19,000	450	180	110	80	60	50	40	Luzerner
6-11⅓ C	9 x 14	33	10′ 0″	4′ 0″	350	28,000	23,000	550	230	140	100	75	60	50	Luzerniere
6-12⅓ C	9 x 16	33	10′ 6″	4′ 6″	400	32,000	27,000	625	265	160	115	85	70	55	Luzette
6-14⅓ C	10 x 16	37	11′ 8″	5′ 0″	450	35,000	30,000	700	290	175	125	95	75	60	Luzidio
6-16⅓ C	11 x 16	37	12′ 0″	5′ 0″	500	40,000	34,000	825	345	210	150	110	90	75	Luzimento
6-18⅓ C	12 x 18	42	13′ 3″	5′ 8″	600	47,000	40,000	1000	420	255	180	140	110	90	Luzola
6-20⅓ C	13 x 18	42	14′ 1″	6′ 0″	700	54,000	47,000	1175	490	300	210	160	130	105	Luzuriaga
6-22⅓ C	14 x 20	48	15′ 0″	6′ 6″	800	62,000	54,000	1350	560	340	240	185	145	120	Lyncean
6-24⅓ C	15 x 20	48	15′ 4″	6′ 6″	900	70,000	62,000	1550	640	390	275	210	165	135	Lynceorum

The driving-wheels of this type are equalized together, the truck is centre-bearing, with swinging bolster and radius bar. For operating short lines, where a limited supply of water and fuel is sufficient, this plan of locomotive has the following advantages:

Having six wheels it is steady, rides smoothly, without plunging, and causes little wear of track.

The fuel is carried on the engine frames at the back. The water supply is carried in a saddle-tank on the boiler or in side-tanks on each side of the boiler. The weight of the water adds to the adhesion and increases the hauling capacity.

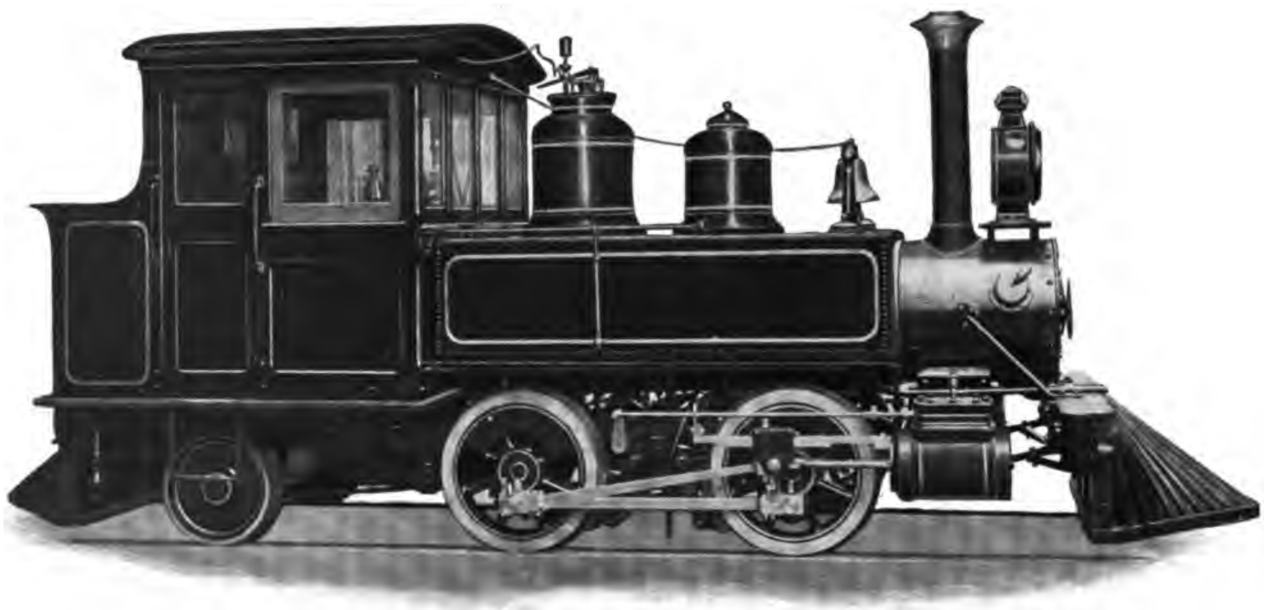
The weight is well distributed; the principal portion is carried on equalizing levers between the driving-wheels. This affords an equal distribution on the four driving-wheels. The pony truck carries the weight of the fuel, with part of the weight of the overhanging fire-box.

The engine can be run either way without turning, and will readily traverse curves of short radius. As the weight is carried on the two side equalizers between the driving-wheels and the centre-pin of the pony truck, every wheel finds a bearing on level or uneven track.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 6-10⅓ C and 6-11⅓ C can be used on rails of 20 to 25 pounds per yard; classes 6-12⅓ C and 6-14⅓ C, 30 to 35 pounds; 6-16⅓ C and 6-18⅓ C, 40 to 45 pounds 6-20⅓ C and 6-22⅓ C, 50 to 60 pounds; and 6-24⅓ C, 65 to 70 pounds.

For remarks on tractive power, see pages 90 to 92.

$\frac{9}{10}$ & 8, ½ T. C.



FOUR-COUPLED TANK LOCOMOTIVE WITH TWO-WHEELED REAR TRUCK.

"FORNEY" TYPE LOCOMOTIVES.

WITH TWO PAIRS OF DRIVING-WHEELS AND FOUR-WHEELED REAR TRUCK.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF TEN SIZES OF THIS PATTERN.

Series 904. Code Word, "Lyncestae."

Class.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water, 8⅓-Pound Gallons.	Weight in Working Order. Pounds.		Load in Tons (of 2240 Pounds) of Cars and Lading.							Code Word.
									On a Grade per Mile of						
			Total.	Of Driving-Wheels.		Total.	On all Driving-Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet or 1½ per cent.	105.6 Feet or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	
8-10⅓ C	8 x 12	28	12′ 9″	3′ 9″	400	27,000	16,000	400	175	105	70	55	40	35	Lyncestium
8-11⅓ C	9 x 14	33	13′ 0″	4′ 0″	500	32,000	20,000	500	220	135	95	70	55	45	Lynched
8-12⅓ C	9 x 16	33	13′ 9″	4′ 6″	600	36,000	23,000	600	250	150	105	80	60	50	Lynching
8-14⅓ C	10 x 16	37	15′ 11″	5′ 0″	700	40,000	26,000	685	285	170	120	90	70	55	Lyncibus
8-16⅓ C	11 x 16	37	16′ 3″	5′ 0″	800	46,000	31,000	820	345	210	145	110	85	70	Lyncida
8-18⅓ C	12 x 18	42	17′ 9″	5′ 8″	900	53,000	37,000	980	410	250	175	130	105	85	Lyncides
8-20⅓ C	13 x 18	42	18′ 8″	6′ 0″	1000	61,000	44,000	1180	490	300	210	160	125	100	Lyncurios
8-22⅓ C	14 x 20	48	20′ 2″	6′ 6″	1100	68,000	50,000	1350	555	340	240	180	145	115	Lyncurium
8-24⅓ C	15 x 20	48	20′ 7″	6′ 6″	1200	76,000	56,000	1500	625	380	265	200	160	130	Lyntraria
8-26⅓ C	16 x 20	48	22′ 0″	7′ 0″	1300	86,000	62,000	1650	690	420	295	225	175	145	Lynxes

Locomotives of this type are compact and powerful for their aggregate weight, and are suitable for suburban passenger traffic, elevated railways, plantation and other service where the run is not long enough to necessitate a separate tender. As the whole weight of the boiler rests on the driving-wheels, the adhesion is ample and the starting power great. They are designed to run either forward or backward, but the wear on driving-wheel flanges is least when running with truck ahead. The driving-wheels are equalized together; the truck is centre-bearing and has a swinging bolster. Locomotives of this plan readily traverse curves of short radius; on the elevated lines in New York and Chicago 4′ 8½″ gauge locomotives of this type are used on curves of 90 feet radius on the main line. As the weight is carried on two side equalizers between the driving-wheels and the centre-pin of the truck, each wheel finds a bearing, notwithstanding any unevenness of the track. The engine, therefore, rides as smoothly as an eight-wheeled or American type locomotive.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 8-10⅓ C and 8-11⅓ C may be used on rails of 20 to 25 pounds per yard; classes 8-12⅓ C to 8-16⅓ C, 30 to 35 pounds; classes 8-18⅓ C and 8-20⅓ C, 40 to 50 pounds; classes 8-22⅓ C to 8-26⅓ C, 55 to 70 pounds.

For remarks on tractive power, see pages 90 to 92.

"FORNEY" TYPE LOCOMOTIVE, WITH FOUR-WHEELED REAR TRUCK

FOUR COUPLED LOCOMOTIVES.

WITH TWO-WHEELED LEADING TRUCK AND SEPARATE TENDER FOR LOCAL PASSENGER, SWITCHING, LOGGING, PLANTATION AND SPECIAL SERVICE.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF NINE SIZES OF THIS PATTERN.

Series 901. Code Word, "Lynxoogen"

Class.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches	Wheel-Base. Total.	Wheel-Base. Of Driving-Wheels.	Capacity of Tender for Water 8⅓-Pound Gallons. 4-Wheeled.	Capacity of Tender 8-Wheeled.	Weight in Working Order. Pounds. Total.	Weight On all Driving-Wheels.	Load in Tons (of 2240 pounds) of Cars and Lading. On a Level.	On a Grade per Mile of 26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet or 1½ per cent.	105.6 Feet or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	Code Word.
6–10 C	8″ x 14″	33	10′ 3″	5′ 0″	500	. . .	20,000	16,000	420	175	105	75	55	40	35	Lynxwet
6–11 C	9″ x 14″	33	10′ 8″	5′ 0″	600	. . .	25,000	20,000	525	220	130	90	70	55	40	Lyonnais
6–12 C	9″ x 16″	33	11′ 2	5′ 6″	700	. . .	28,000	23,000	600	250	150	105	80	60	50	Lypornix
6–14 C	10″ x 16″	37	11′ 7	5′ 6″	800	. . .	32,000	26,000	685	285	170	115	90	70	55	Lyprops
6–16 C	11″ x 16″	37	12′ 5	6′ 0″	1000	1000	37,000	31,000	830	340	205	140	105	80	65	Lypsimene
6–18 C	12″ x 18″	42	13′ 0″	6′ 0″	. . .	1200	44,000	37,000	980	405	245	170	125	100	80	Lyrcæus
6–20 C	13″ x 18″	42	13′ 10″	7′ 0″	. . .	1400	52,000	44,000	1170	480	290	200	150	115	95	Lyrcearum
6–22 C	14″ x 20″	48	15′ 2″	7′ 6″	. . .	1600	59,000	50,000	1325	540	325	225	170	130	105	Lyrcius
6–24 C	15″ x 20″	48	15′ 2″	7′ 6″	. . .	1800	66,000	56,000	1500	615	370	260	190	150	120	Lyréide

Locomotives of this plan are suitable for local passenger, switching, logging and special service, where the runs are short and speed moderate. The fire-box is placed over the rear axle. This form of fire-box is suitable for burning coal or wood. Two pairs of wheels are equalized together,—either the two pairs of driving-wheels or the front pair of driving-wheels with the pony truck. The pony truck has a swinging bolster and radius bar. Engines of this type, owing to the action of the pony truck and the short wheel-bases, readily traverse curves of short radius.

Assuming that steel rails, properly supported by crossties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each 10 pounds weight per yard of rail, classes 6-10 C and 6-11 C can be used on rails of 20 to 25 pounds per yard; classes 6-12 C to 6-16 C, 30 to 35 pounds; classes 6-18 C and 6-20 C, 40 to 50 pounds; classes 6-22 C and 6-24 C, 55 to 65 pounds. For remarks on tractive power, see pages 90 to 92.

9/10 & 8, T x 20.

FOUR-COUPLED LOCOMOTIVE WITH LEADING TRUCK.

FOUR-COUPLED "DOUBLE-ENDER" TANK LOCOMOTIVES.

WITH TWO-WHEELED LEADING AND TRAILING TRUCKS.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF NINE SIZES OF THIS PATTERN.

Series 905. Code Word, "Lyrical."

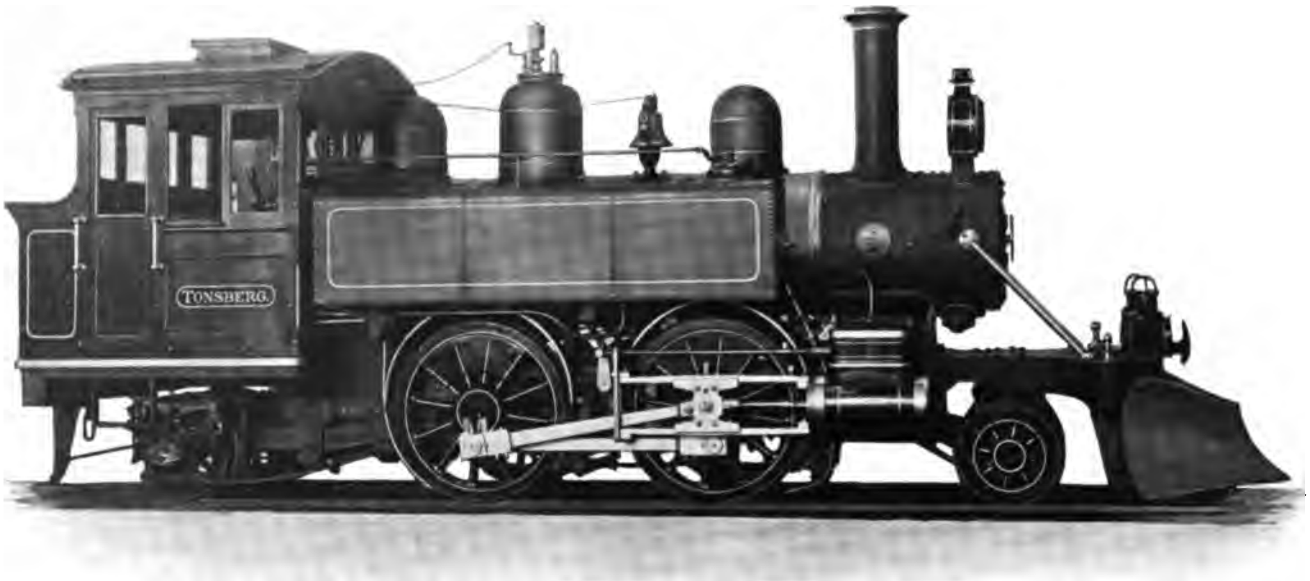
CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water, 8⅓-Pound Gallons.	Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.							CODE WORD.
								On a Level.	On a Grade per Mile of						
			Total.	Of Driving-Wheels.	Tank on Boiler or Engine Frames.	Total.	On all Driving-Wheels.		26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	
8-10¼ C	8 x 12	33 to 37	15′ 0″	4′ 3″	350	26,000	15,000	325	140	85	60	40	30	25	Lyrichord
8-11¼ C	9 x 14	33 to 37	15′ 7″	4′ 6″	400	32,000	19,000	425	185	110	75	55	45	35	Lyricinis
8-12¼ C	9 x 16	37 to 41	15′ 10″	4′ 6″	450	35,000	22,000	500	205	125	85	65	50	40	Lyricinum
8-14¼ C	10 x 16	37 to 41	17′ 8″	5′ 0″	500	40,000	26,000	600	250	150	105	75	60	50	Lyricism
8-16¼ C	11 x 16	37 to 41	18′ 0″	5′ 0″	600	46,000	30,000	725	305	185	130	95	75	60	Lyricorum
8-18¼ C	12 x 18	41 to 45	19′ 7″	5′ 8″	700	58,000	38,000	925	385	230	160	120	95	75	Lyricos
8-20¼ C	13 x 18	41 to 45	20′ 8″	6′ 0″	800	66,000	44,000	1050	440	265	185	140	110	85	Lyricum
8-22¼ C	14 x 20	45 to 48	22′ 0″	6′ 6″	900	76,000	52,000	1275	530	320	225	170	130	105	Lyrifere
8-24¼ C	15 x 20	48	22′ 6″	6′ 6″	1000	84,000	58,000	1450	590	360	250	190	150	120	Lyriforme

This type of engine is suitable for suburban passenger, switching and logging service, where it is desirable to run forward and backward without turning, and where the run is not long enough to necessitate a separate tender. The front truck is centre-bearing and is equalized with the forward driving-wheels. The rear truck is side-bearing and is equalized with the rear driving-wheels. The back of the engine is thus carried on two side-bearings at the fulcrums. The engine will, therefore, ride smoothly, and all the wheels find a bearing on the most uneven track. Each track has a swinging bolster and radius-bar and protects the flanges of the driving-wheels when curving. The short rigid wheel-base of this plan, in proportion to its total wheel-base and power, enables it to traverse curves of short radius.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 8-10¼ C and 8-11¼ C can be used on rails of 15 to 20 pounds per yard; classes 8-12¼ C to 8-16¼ C, 25 to 35 pounds; classes 8-18¼ C and 8-20¼ C, 40 to 45 pounds; classes 8-22¼ C and 8-24¼ C, 50 to 60 pounds.

For remarks on tractive power, see pages 90 to 92.

$\frac{2}{10}$ & 8, ½ T. C.



FOUR-COUPLED "DOUBLE-ENDER" TANK LOCOMOTIVE.

SIX-COUPLED TANK LOCOMOTIVES, WITH TWO-WHEELED REAR TRUCK.

FOR PLANTATION, LOGGING, OR SPECIAL SERVICE.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF ELEVEN SIZES OF THIS PATTERN.

Series 916. Code Word, "Lyriker."

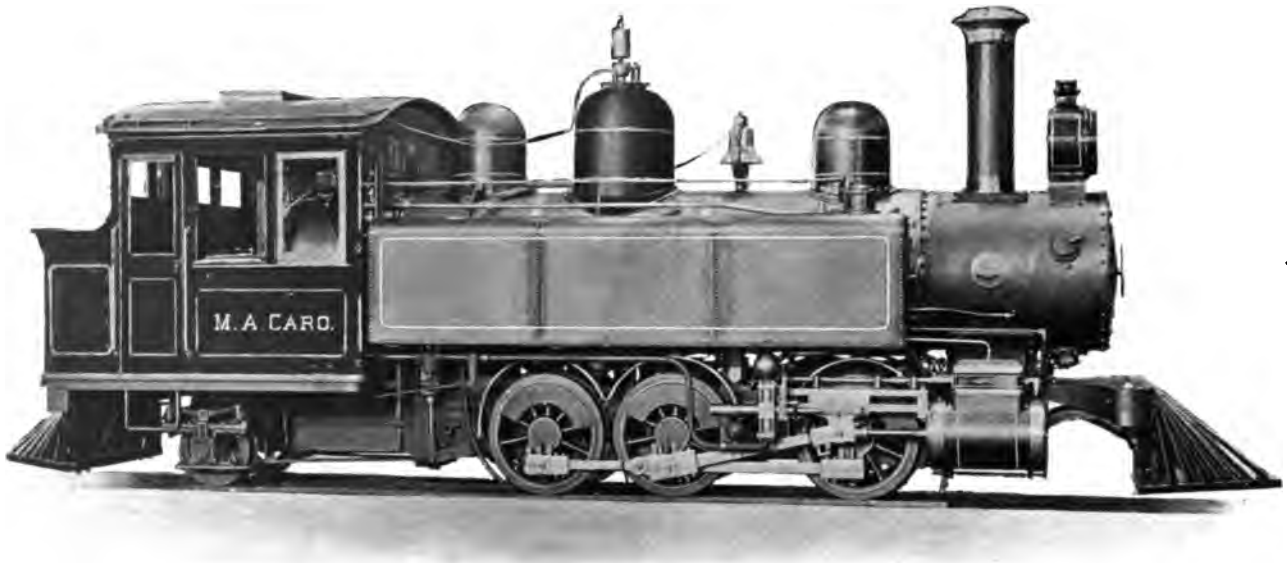
Class.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water, 8⅓-Pound Gallons.	Weight in Working Order. Pounds.		Load in Tons (of 2240 Pounds) of Cars and Lading.							Code Word.
									On a Grade per Mile of						
			Total.	Of Driving-Wheels.	Tank on Boiler.	Total.	On all Driving-Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	
8–10⅓ D	8 x 12	28	11′ 3″	5′ 5″	350	23,000	19,000	425	175	105	75	55	45	35	Lyrique
8–11⅓ D	9 x 14	33	12′ 9″	6′ 6″	400	28,000	24,000	550	235	140	100	75	60	50	Lyrisch
8–12⅓ D	9 x 16	33	13′ 4″	7′ 4″	450	30,500	26,000	600	255	155	110	80	65	55	Lyrisches
8–14⅓ D	10 x 16	38	14′ 2″	7′ 6″	500	34,000	29,000	675	275	165	120	90	70	60	Lyrisme
8–16⅓ D	11 x 16	38	14′ 9″	7′ 9″	550	42,000	36,000	825	355	215	155	110	90	75	Lyristarum
8–18⅓ D	12 x 18	44	16′ 3″	8′ 8″	600	47,000	41,000	975	400	245	170	130	105	85	Lyristes
8–20⅓ D	13 x 18	44	17′ 1″	9′ 0″	700	55,000	48,000	1125	470	285	200	150	120	100	Lyristria
8–22⅓ D	14 x 20	48	17′ 11″	9′ 5″	800	63,000	56,000	1350	560	340	240	185	145	120	Lyrnesi
8–24⅓ D	15 x 20	48	18′ 5″	9′ 7″	900	71,000	63,000	1525	625	380	270	205	165	135	Lyrnesium
8–24⅓ D	15 x 22	48	18′ 8″	9′ 10″	950	77,000	68,000	1625	670	410	290	220	175	145	Lyrnesos
8–26⅓ D	16 x 22	48	19′ 2″	10′ 0″	1000	86,000	76,000	1825	760	465	330	250	200	165	Lyrnessus

Locomotives of this plan are suitable for plantation, logging, or special service, where the runs are not long enough to require a separate tender. The addition of a truck avoids the plunging or galloping motion to which a four-wheeled or six-wheeled tank locomotive is subject when used at more than a moderate speed. The increased space back of the cab also permits of greater coal space and more room for the enginemen than is practicable without the truck. The three pairs of driving wheels are equalized together; the truck is centre bearing, and has a swinging bolster and radius bar.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, Classes 8–10⅓ D to 8–14⅓ D can be used on rails of 20 to 25 pounds per yard; Classes 8–16⅓ D and 8–18⅓ D, 30 to 35 pounds; Classes 8–20⅓ D and 8–22⅓ D, 40 to 45 pounds; Class 8–24⅓ D, 50 pounds, and Class 8–26⅓ D, 60 pounds.

For remarks on tractive power, see pages 90 to 92.

$\frac{9}{10}$ & 8, ½ T. C.



SIX-COUPLED TANK LOCOMOTIVE, WITH TWO WHEELED REAR TRUCK

SIX-COUPLED "DOUBLE-ENDER" TANK LOCOMOTIVES.

WITH TWO-WHEELED LEADING AND TRAILING TRUCKS,

FOR SUBURBAN PASSENGER AND LOCAL FREIGHT SERVICE.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF NINE SIZES OF THIS PATTERN.

Series 912. Code Word, "Lyrodie."

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water, 8⅓-Pound Gallons.	Weight in Working Order, Including Water. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.							CODE WORD
			Total.	Of Driving-Wheels.	Tank on Boiler.	Total.	On all Driving-Wheels.	On a Level.	On a Grade per Mile of 26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	
10-16¼ D	11 x 16	38	19′ 6″	8′ 8″	550	48,000	34,000	825	340	205	145	110	85	70	Lyrophore
10-18¼ D	12 x 18	44	20′ 8″	9′ 0″	650	54,000	40,000	950	400	240	170	125	100	80	Lyrops
10-20¼ D	13 x 18	44	21′ 3″	9′ 4″	700	62,000	46,000	1125	460	280	200	150	120	95	Lysandrien
10-22¼ D	14 x 20	48	22′ 3″	9′ 8″	850	75,000	56,000	1325	555	335	235	180	140	115	Lysandro
10-24¼ D	15 x 20	48	22′ 2″	9′ 9″	900	80,000	60,000	1500	620	380	265	200	160	130	Lysanias
10-24½ D	15 x 22	48	23′ 3″	10′ 0″	1000	88,000	66,000	1650	690	420	295	225	175	145	Lysantem
10-26¼ D	16 x 22	48	24′ 6″	11′ 0″	1100	96,000	72,000	1800	745	450	320	240	190	155	Lysantis
10-28¼ D	17 x 22	48	24′ 10″	11′ 0″	1200	104,000	80,000	2015	835	510	360	270	215	175	Lysas
10-30¼ D	18 x 22	48	26′ 0″	12′ 0″	1300	114,000	90,000	2275	935	570	405	305	245	200	Lysiaci

This plan is suitable for suburban passenger or local freight service, where it is desirable to run forward or backward without turning, and where an engine with only two pairs of driving-wheels, but otherwise of the same design, would not afford adequate adhesion, or where the required weight, if carried by only two pairs of driving-wheels, would be greater than the rails could safely bear. It has the following advantages:

The forward truck is equalized with the forward pair of driving-wheels, and the middle and rear pairs of driving-wheels are equalized with the rear truck. The front truck is centre bearing; the trailing truck is side-bearing. Each truck has a swinging bolster and radius bar. This arrangement enables the engine to ride smoothly and find a bearing on the most uneven track. The truck guides the engine around curves and relieves the flanges of the driving-wheels of excessive friction.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 10-16¼ D and 10-18¼ D can be used on rails of 25 to 30 pounds per yard; classes 10-20¼ D and 10-22¼ D, 35 to 40 pounds; classes 10-24¼ D to 10 26¼ D, 45 to 55 pounds; classes 10-28¼ D and 10-30¼ D, 60 to 70 pounds.

For remarks on tractive power, see pages 90 to 92.

10 & 6 ½ T. C.

SIX-COUPLED "DOUBLE-ENDER" TANK LOCOMOTIVE.

EIGHT-COUPLED "DOUBLE-ENDER" TANK LOCOMOTIVES.

WITH TWO-WHEELED LEADING AND TRAILING TRUCKS, FOR LOCAL FREIGHT SERVICE.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF FIVE SIZES OF THIS PATTERN.

Series 915. Code Word, "Lysiacorum."

Class.	Cylinders, Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base. Total.	Wheel-Base. Of Driving-Wheels.	Capacity of Tank for Water, 8⅓-Pound Gallons. Tank on Boiler.	Weight in Working Order, Including Water. Pounds. Total.	Weight in Working Order. On all Driving-Wheels.	Load in Tons (of 2240 Pounds) of Cars and Lading. On a Level.	On a Grade per Mile of 26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	Code Word.
12-26¼ E	16 x 20	42	25′ 0″	12′ 3″	1100	98,000	76,000	1800	745	450	315	240	190	155	Lysiacos
12-28¼ E	17 x 20	42	26′ 0″	12′ 6″	1200	106,000	83,000	1975	810	490	345	260	205	170	Lysiacum
12-30¼ E	18 x 20	42	27′ 8″	13′ 2″	1300	117,000	91,000	2150	890	540	380	285	225	185	Lysiades
12-32¼ E	19 x 22	48	29′ 0″	13′10″	1400	127,000	98,000	2325	955	580	405	305	245	200	Lysianasse
12-34¼ E	20 x 22	48	30′ 6″	14′ 6″	1500	139,000	106,000	2500	1030	625	440	330	265	215	Lysianax

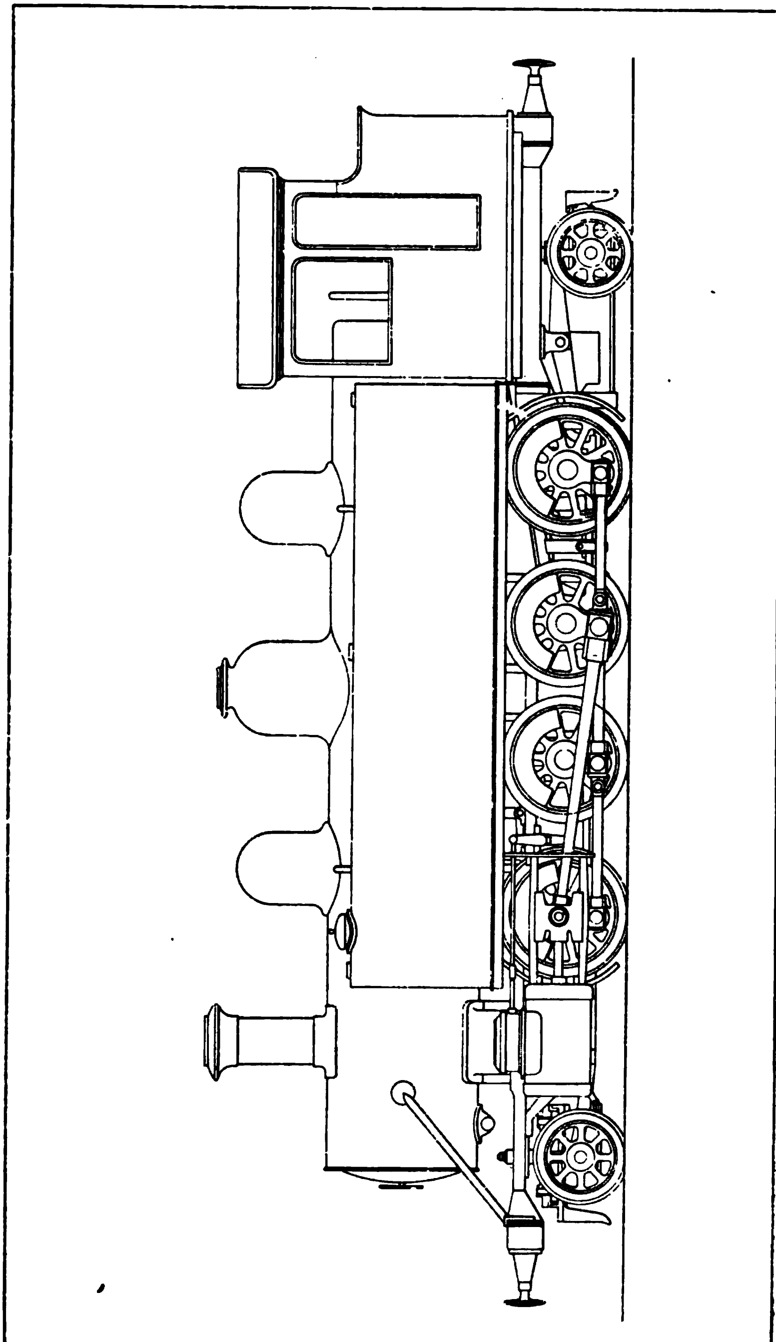
This type is suitable for local freight service, where it is desirable to run forward or backward without turning, and where an engine with only three pairs of driving-wheels, but otherwise of the same design, would not afford adequate adhesion, or, where the required weight, if carried by only three pairs of driving-wheels, would be greater than the rails could safely bear. It has the following advantages:

The forward truck is equalized with the two forward pairs of driving-wheels, and the rear truck is equalized with the two rear pairs of driving-wheels. The front truck is centre-bearing; the trailing truck is side-bearing. Each truck has a swinging bolster and radius bar. This arrangement enables the engine to ride smoothly and find a bearing on the most uneven track. The trucks guide the engine around curves and relieve the flanges of the driving-wheels of excessive friction.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 12-26¼ E and 12-28¼ E can be used on rails of 45 to 50 pounds per yard; and classes 12-30¼ E to 12-34¼ E, 55 to 65 pounds.

For remarks on tractive power, see pages 90 to 92.

$\frac{2}{10}$ & 8, ½ T. C.



EIGHT-COUPLED "DOUBLE-ENDER" TANK LOCOMOTIVE.

SIX-COUPLED SWITCHING LOCOMOTIVES.

TWO SIDE-TANKS OR SADDLE-TANK ON BOILER, FOR SWITCHING, LOGGING AND PLANTATION SERVICE.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF ELEVEN SIZES OF THIS PATTERN

Series 909. Code Word, "Lysidice."

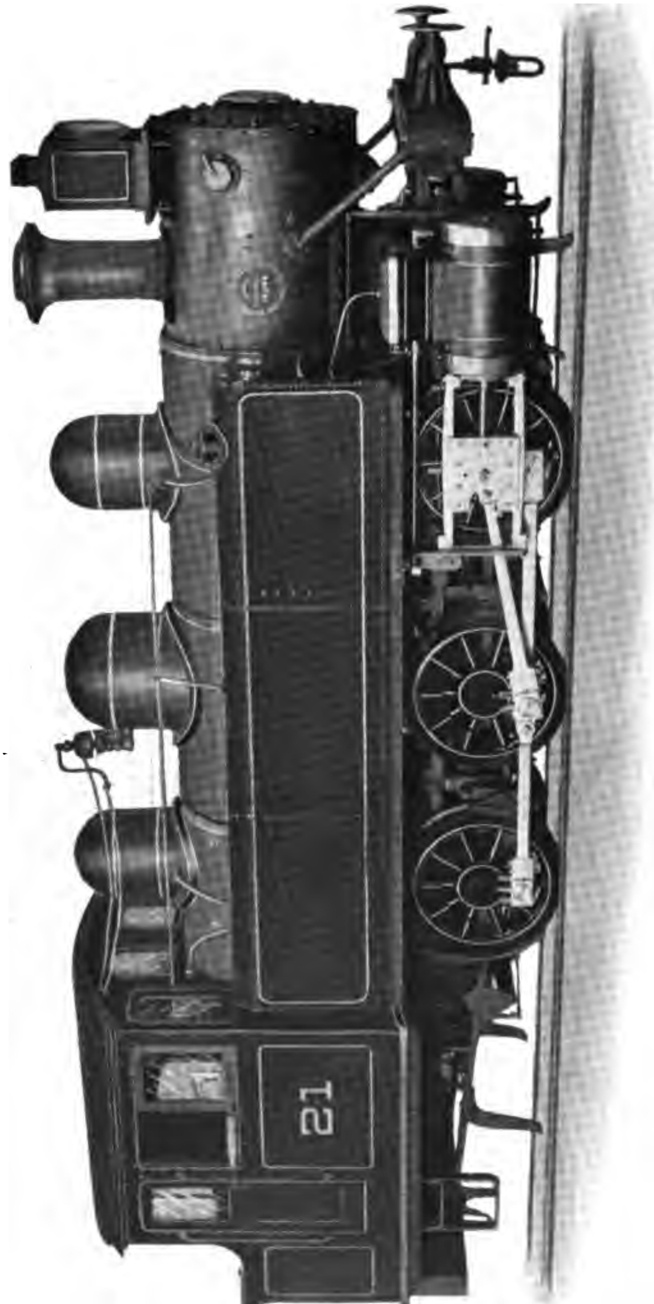
Class.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.	Capacity of Tank for Water, 8⅓-Pound Gallons.	Weight in Working Order. Pounds.	Load in Tons (of 2240 pounds) of Cars and Lading. On a Level.	On a Grade per Mile of 26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	Code Word.
6–8 D	7 x 10	22	4′ 10″	200	14,000	325	145	85	60	45	35	30	Lysidicus
6–10 D	8 x 12	28	5′ 5″	250	18,000	425	180	110	75	60	50	40	Lysidis
6–11 D	9 x 14	30	6′ 3″	300	24,000	600	250	150	105	80	65	50	Lysikles
6–12 D	9 x 16	33	6′ 11″	350	26,000	650	270	165	115	90	70	55	Lysimache
6–14 D	10 x 16	33	7′ 6″	400	31,000	750	315	190	135	105	85	70	Lysimachia
6–16 D	11 x 16	33 to 38	7′ 8″	450	35,000	825	350	215	150	115	90	75	Lysimachos
6–18 D	12 x 18	38 to 42	8′ 6″	500	42,000	1025	430	260	185	140	115	90	Lysimaque
6–20 D	13 x 20	38 to 42	9′ 0″	600	51,000	1300	540	330	235	175	140	115	Lysimelia
6–22 D	14 x 20	38 to 42	10′ 0″	700	58,000	1500	610	375	265	200	160	130	Lysimetre
6–24 D	15 x 22	42 to 48	10′ 6″	800	68,000	1700	710	435	310	235	190	155	Lysineme
6–26 D	16 x 22	42 to 48	11′ 0″	1000	78,000	1900	800	490	350	265	215	175	Lysinia

This type is suitable for switching, logging, or plantation service, where short runs render a tender unnecessary, or, where the weight of the engine, if carried on only two pairs of wheels, would be greater than the rails could bear.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 6-8 D and 6-10 D can be used on rails of 10 to 12 pounds per yard; classes 6-11 D and 6-12 D, 15 to 20 pounds; classes 6-14 D to 6-18 D, 25 to 30 pounds; 6-20 D and 6-22 D, 35 to 45 pounds; 6-24 D and 6-26 D, 50 to 55 pounds. If practicable, however, it is desirable to have rails heavy enough to give a greater factor of strength.

For remarks on tractive power, see pages 90 to 92.

9/10 & 8, ½ T. C.



SIX-COUPLED LOCOMOTIVE, WITH SIDE-TANKS.

SIX-COUPLED LOCOMOTIVES, WITH SEPARATE TENDERS,

FOR SWITCHING, LOGGING, AND PLANTATION SERVICE.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF TEN SIZES OF THIS PATTERN.

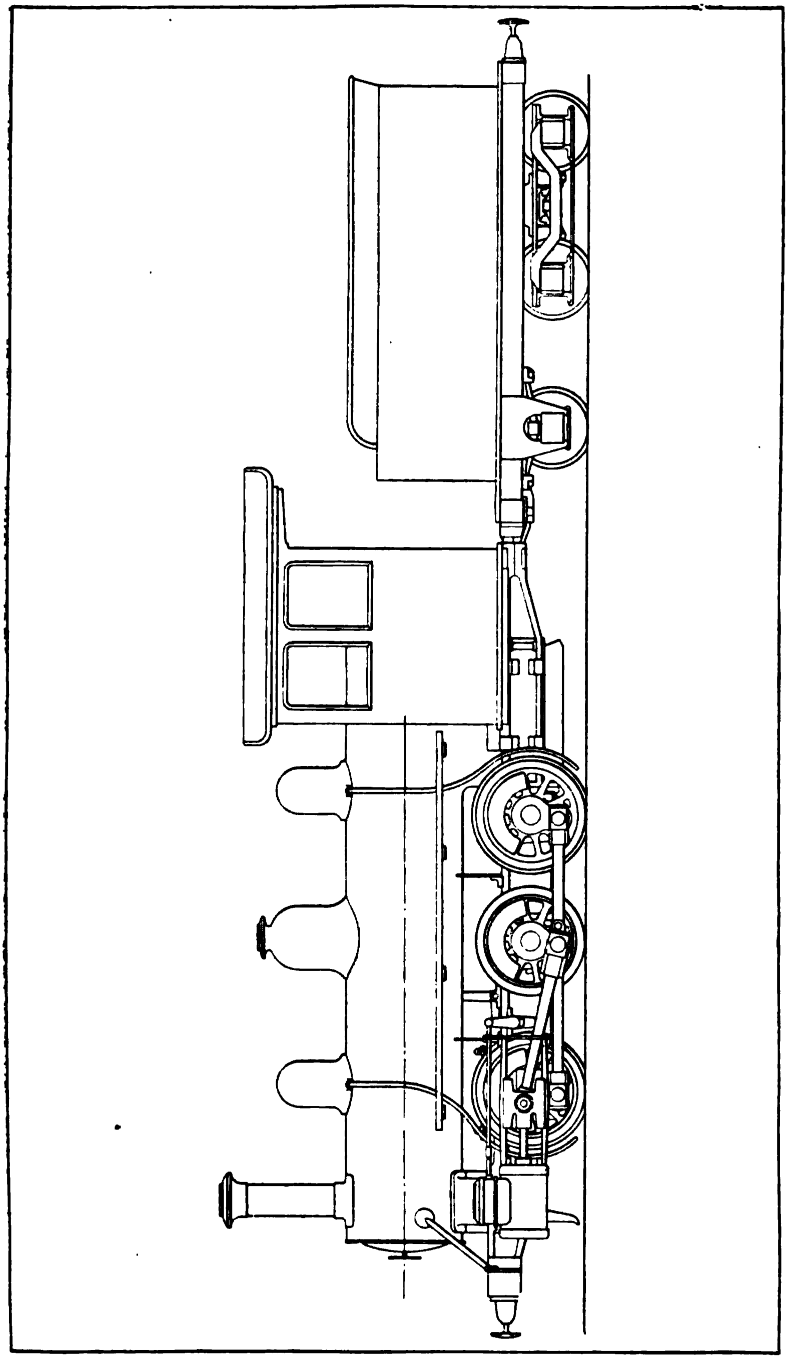
Series 910. Code Word, "Lysionote."

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.	Capacity of Tender for Water, 8⅓-Pound Gallons.		Weight of Engine in Working Order. Pounds.	LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.							CODE WORD
							On a Level.	On a Grade per Mile of						
				4-Wheeled.	6-Wheeled.			26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.	
6-8 D	7 x 10	22	4′ 10″	400		12,000	300	130	80	55	40	30	25	Lysipome
6-10 D	8 x 12	28	5′ 5″	500		16,000	400	175	105	75	55	45	35	Lysippe
6-11 D	9 x 14	30	6′ 3″	550		21,000	550	230	140	95	75	55	45	Lysippos
6 12 D	9 x 16	33	6′ 11″	600		23,000	600	255	155	105	80	65	50	Lysippum
6 14 D	10 x 16	33	7′ 6″	700	1000	27,000	700	295	180	125	95	75	60	Lysitani
6-16 D	11 x 16	33 to 38	7′ 8″	800	1100	31,000	800	340	205	135	105	85	65	Lysithides
6-18 D	12 x 18	38 to 42	8′ 6″	900	1200	37,000	975	345	245	170	130	100	80	Lysithoe
6-20 D	13 x 20	38 to 42	9′ 0″	1000	1400	45,000	1200	495	300	210	155	125	100	Lysithous
6-22 D	14 x 20	38 to 42	10′ 0″		1500	52,000	1400	575	345	245	185	145	115	Lysmate
6-24 D	15 x 22	42 to 48	10′ 6″		1600	60,000	1600	665	400	280	210	170	135	Lystreni

This type is suitable for switching, logging, plantation, or mixed service. It is especially suitable where the conditions make it advisable to distribute the weight over more than two pairs of driving-wheels. In the heavier classes of narrow-gauge switching engines, the six-wheeled type, with tender, is preferable, to avoid raising the centre of gravity. The separate tender is somewhat more convenient, and, as it affords a greater supply of fuel and water than a tank engine, longer runs are permissible. The water capacity of the tender mentioned for the respective classes is generally found sufficient, but it can be varied to suit special requirements.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 6-8 D and 6-10 D can be used on rails of 10 to 12 pounds per yard; classes 6-11 D to 6-14 D, 15 to 20 pounds; classes 6-16 D to 6-20 D, 25 to 35 pounds; classes 6-22 D and 6-24 D, 40 to 45 pounds.

For remarks on tractive power, see pages 90 to 92.

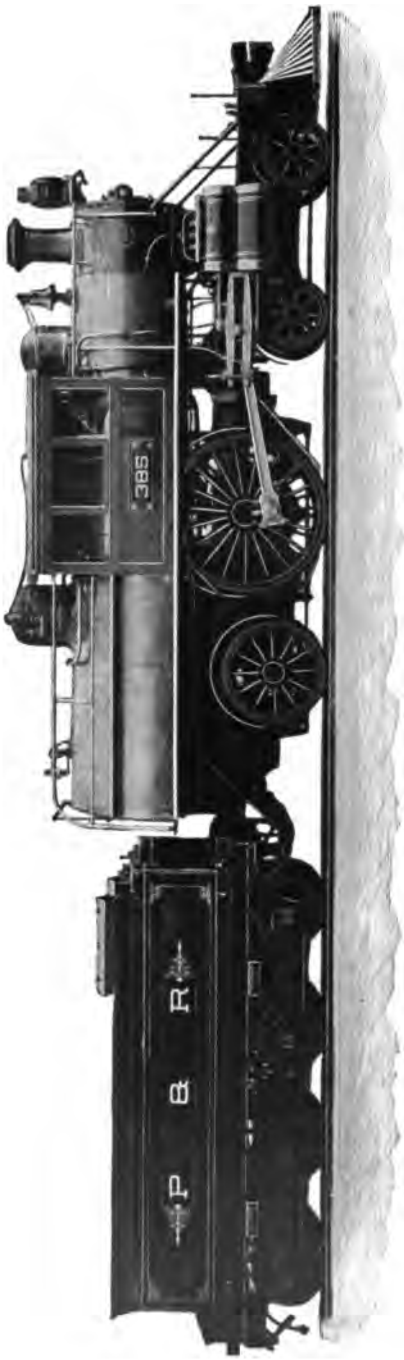


SIX-COUPLED LOCOMOTIVE, WITH SEPARATE TENDER.

SPECIAL CONDITIONS OF SERVICE.

THE locomotives described in the foregoing tables comprise designs adapted to the conditions of service usually prevailing, and the dimensions of boilers and fire-boxes are generally based upon the presumption that the fuel will be coal of ordinarily good quality. Any of these designs can, however, be modified to meet unusual requirements, and on pages 115 and 145 locomotives are shown having enlarged grate areas adapted for inferior coal. Trials of these locomotives having such special designs of fire-boxes and grates show that excellent results are obtained with coal ordinarily considered unsuitable for such use. To determine the suitability of any fuel for locomotives, a small quantity of same may be sent to the Baldwin Locomotive Works for analysis and laboratory tests, when, if practicable, specifications and designs will be submitted for locomotives guaranteed to meet the conditions thus ascertained.

FREIGHT LOCOMOTIVE WITH LARGE FIRE-BOX.



EXPRESS LOCOMOTIVE, WITH SINGLE PAIR OF DRIVING WHEELS PHILADELPHIA AND READING RAILROAD.

COMPOUND LOCOMOTIVES.

Any of the locomotives described in the foregoing pages can be constructed upon the Baldwin or Vauclain compound system by substituting for the single-expansion cylinder diameters given, the equivalent diameters of compound cylinders indicated by the following table:

Diameter of Cylinders						
Single Expansion.			Compound.			
140 Lbs. Pressure.	160 Lbs. Pressure.	180 Lbs. Pressure.	180 Lbs. Pressure.		200 Lbs. Pressure.	
			H. P.	L. P.	H. P.	L. P.
10½″	10″	9½″	7″	12″	6½″	11″
11½″	11″	10½″	7½″	13″	7″	12″
13″	12″	11″	8½″	14″	7½″	13″
14″	13″	12″	9″	15″	8½″	14″
15″	14″	13″	9½″	16″	9″	15″
16″	15″	14″	10″	17″	9½″	16″
17″	16″	15″	11″	18″	10″	17″
18″	17″	16″	11½″	19″	11″	18″
19″	18″	17″	12″	20″	11½″	19″
19½″	18½″	17½″	12½″	21″	12″	20″
20½″	19″	18″	13″	22″	12½″	21″
21½″	20″	19″	13½″	23″	13″	22″
22½″	21″	20″	14″	24″	13½″	23″
23½″	22″	20½″	15″	25″	14″	24″
24½″	23″	21½″	15½″	26″	15″	25″
25½″	24″	22½″	16″	27″	15½″	26″
27″	25″	23½″	17″	28″	16″	27″
	25½″	24″	17½″	29″	17″	28″
		24½″	18″	30″	17½″	29″

TRAIN OF TWENTY COMPOUND LOCOMOTIVES FOR CHICAGO AND SOUTH SIDE RAPID TRANSIT RAILROAD.

THE "VAUCLAIN" SYSTEM OF COMPOUND LOCOMOTIVES.

PASSENGER LOCOMOTIVE, ALTOONA & PHILLIPSBURG CONNECTING RAILROAD.

DESCRIPTION.

In designing the "Vauclain" system of compound locomotives, the aim has been:

1. To produce a compound locomotive of the greatest efficiency, with the utmost simplicity of parts and the least possible deviation from existing practice. To realize the maximum econmy of fuel and water.

2. To develop the same amount of power on each side of the locomotive, and avoid the racking of machinery resulting from unequal distribution of power.

3. To insure at least as great efficiency in every respect as in a single-expansion locomotive of similar weight and type.

4. To insure the least possible difference in cost of repairs.

5. To insure the least possible departure from the method of handling single-expansion locomotives; to apply equally to passenger or freight locomotives for all gauges of track, and to withstand the rough usage incidental to ordinary railroad service.

TEN-WHEEL DOUBLE-ENDER PASSENGER LOCOMOTIVE WELLINGTON & MANAWATU RAILWAY

NARROW-GAUGE FREIGHT LOCOMOTIVE, BAHIA EXTENSION.

The principal features of construction are as follows:

CYLINDERS.

The cylinders consist of one high-pressure and one low-pressure for each side, the ratio of the volumes being as nearly three to one as the employment of convenient measurements will allow. They are cast in one piece with the valve-chamber and saddle, the cylinders being in the same vertical plane, and as close together as they can be with adequate walls between them.

Where the front rails of the frames are single bars, the high-pressure cylinder is usually put on top, as shown in Fig. 1, but when the front rails of frames are double, the low-pressure cylinder is usually on top, as shown in Fig. 2.

FIG. 2.

FIG 1.

MOGUL LOCOMOTIVE TIKU HO RAILWAY JAPAN.

The former (Fig. 1) is used in "eight-wheel" or American type passenger locomotives, and in "ten-wheeled" locomotives, while the latter (Fig. 2) is used in Mogul, Consolidation and Decapod locomotives; for the various other classes of locomotives the most suitable arrangement is determined by the style of frames.

Fig. 3 shows the arrangement of the cylinders in relation to the valve.

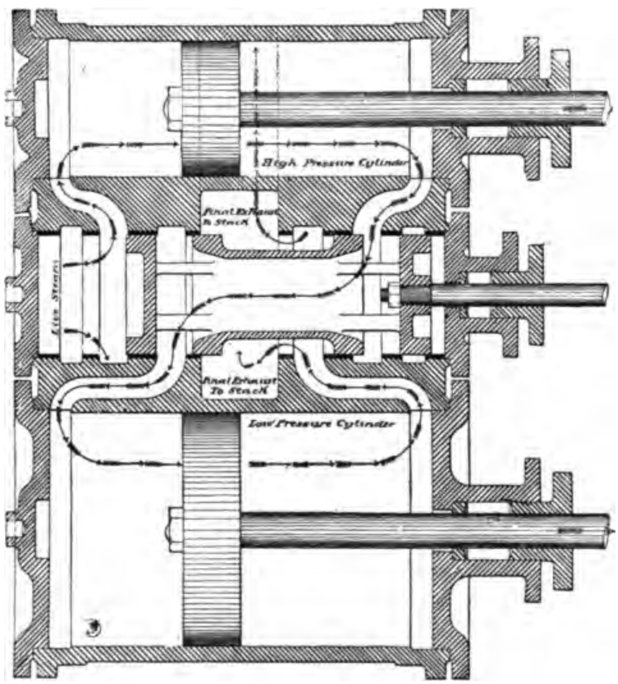


FIG. 3

The valve employed to distribute the steam to the cylinders is of the piston type, working in a cylindrical steam-chest located in the saddle of the cylinder casting between the cylinders and the smoke-box, and as close to the cylinders as convenience will permit.

As the steam-chest must have the necessary steam passages cast in it and dressed accurately to the required sizes, the main passages in the cylinder casting leading thereto are cast wider

TEN-WHEEL PASSENGER LOCOMOTIVE SOUTH EASTERN RAILROAD OF RUSSIA.

than the finished ports. The steam-chest is bored out enough larger than the diameter of the valve to permit the use of a hard cast iron bushing (Fig. 4). This bushing is forced into the steam-chest under such pressure as to prevent the escape of

FIG. 4.

steam from one steam passage to another except by the action of the valve. Thus an opportunity is given to machine accurately all the various ports, so that the admission of steam is uniform under all conditions of service.

The valve, which is of the piston type,—double and hollow,— as shown by Fig. 5, controls the steam admission and exhaust of both cylinders. The exhaust steam from the high-pressure cylinder becomes the supply steam for the low-pressure cylinder.

FIG. 5.

As the supply steam for the high-pressure cylinder enters the steam-chest at both ends, the valve is in perfect balance, except the slight variation caused by the area of the valve-stem at the back end. This variation is an advantage in case the valve or its connection to the valve-rod should be broken, as it holds them together. Cases are reported where compound locomotives of

this system have hauled passenger trains long distances with broken valve-stems and broken valves, the parts being kept in their proper relation while running by the compression due to the variation mentioned. To avoid the possibility of breaking, it is the present practice to pass the valve-stem through the valve and secure it by a nut on the front end.

Cast iron packing rings are fitted to the valve and constitute the edges of the valve. They are prevented from entering the steam-ports when the valve is in motion by the narrow bridge across the steam-ports of the bushing, as shown in Fig. 4. The operation of the valve is clearly shown by Fig. 3, the direction of the steam being indicated by arrows.

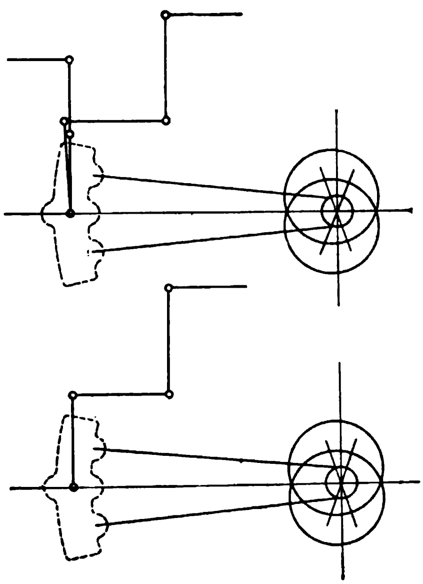


FIG. 6.

When the low-pressure cylinder is on top, as shown by Fig. 2, the double front rail prevents the use of the ordinary rock-shaft and box, and the valve motion is then what is called "direct acting," changing the location of the eccentrics on the axle in relation to the crank-pin. When the low-pressure cylinder is underneath, the rock-shaft is employed, and the eccentrics are placed in the usual position, the valve motion is termed "indirect acting." Fig. 6 shows the relation of the eccentrics with and without the rocker-shaft. Great care should be taken by mechanics, when setting the valves on these locomotives, to observe this difference and not get the eccentrics improperly located on the axle. If the crank-pin is placed on the forward centre, the eccentric-rods will not be crossed when the rocker-arm or indirect motion is used, but will be crossed when no rocker-arm or direct motion is used. Serious complications have arisen from this being disregarded.

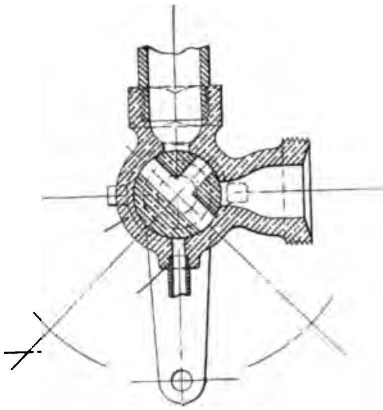
Various methods have been employed to transfer the motion from the links to the valve-rod. That which has proved most satisfactory is to attach the ends of the link and valve-rods to the arms of an intermediate oscillating shaft. This arrangement allows for the free vertical movement of the end of the rod attached to the link, and gives a parallel movement to the valve-rod. It also makes it convenient to obtain any required lateral variation in the line of the two rods. These parts are thoroughly case-hardened, and with reasonable care should wear indefinitely. It is preferable, however, to use a rock-shaft when possible, as there is then less departure from ordinary locomotive practice.

FIG. 7.

The cross-head is shown by Fig. 7. It is made of open-hearth cast steel and is machined accurately to size. The bearings for the guide-bars are covered with a thin coating of block tin, about one-sixteenth inch thick, which wears well and prevents heating. The holes for the piston-rods are bored so that the piston-rods will be perfectly parallel, and are tapered to insure a perfect fit.

The piston shown by Fig. 8 is made with either cast iron or cast steel heads, and is as light as possible. The rods, which are of triple-refined iron, are ground perfectly true to insure

FIG. 8



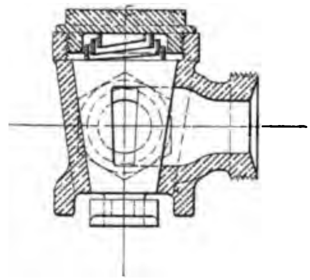


FIG. 9

good service in connection with metallic packing for the stuffing boxes. The diameter of both piston-rods is the same, both having equal work to perform. They are made large enough to resist strains due to any unequal pressure that may come upon them in starting the locomotive from a state of rest. The cross-head end has a shoulder which prevents the piston-rod being forced into the cross-head, and at the same time permits the cross-head end and the body of the piston-rod to be of one diameter, thus permitting vibratory strains to act throughout the entire length of the rod instead of concentrating them at the shoulder next to the cross-head. The piston-rods are secured to the cross-head by large nuts, and these in turn are prevented from coming loose by taper keys driven tightly against them.

It is obvious that in starting these locomotives with full trains from a state of rest, it is necessary to admit steam to the low-pressure cylinder as well as to the high-pressure cylinder, which is accomplished by the use of a starting valve (Fig. 9). This is merely a pass-by valve which is opened to admit steam to pass from one end of the high-pressure cylinder to the other end and thence through the exhaust to the low-pressure cylinder. This is more clearly shown at E in Fig. 10. The same cock acts as a cylinder cock for the high-pressure cylinder and is operated by the same lever that operates the ordinary cylinder cocks, thus making a simple and efficient device, and one that need not become disarranged. This valve should be kept shut as much as possible, as its indiscriminate use reduces the economy and makes the locomotive "logy."

As is usual in all engines, air valves are placed in the main steam passage of the high-pressure cylinder. Additional air

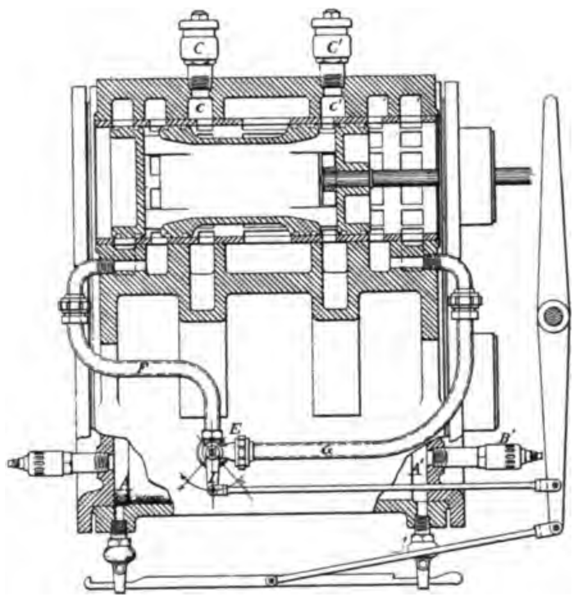


FIG. 10.

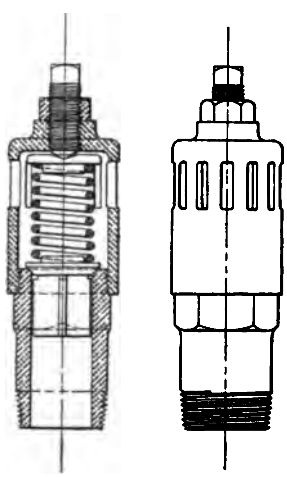


FIG. 11.

valves, marked C and C' in Fig. 10, are placed in the steam passages of the low-pressure cylinders to supply them with sufficient air to prevent the formation of a vacuum, which would draw cinders into the steam-chest and cylinders.

Water relief valves (Fig. 11) are applied to the low-pressure cylinders, and attached to the front and back cylinder heads, to prevent the rupture of the cylinder in case a careless engineer should permit the cylinders to be charged with water, or to relieve excessive pressure of any kind.

In all other respects the locomotive is the same as the ordinary single-expansion locomotive.

OPERATION.

It is not surprising, in view of their differences of opinion respecting single-expansion locomotives, that there has been much controversy among engineers and firemen in regard to the operation of compound locomotives of this system. The first thing the engineer must learn is to use the reverse lever for what

SIX-COUPLED DOUBLE-ENDED LOCOMOTIVE, GOVERNMENT OF VICTORIA.

it is intended, that is, he must not hesitate to move it forward when ascending a grade if the locomotive shows signs of slowing up. The reverse quadrant is always so made that it is impossible to cut off steam in the high-pressure cylinder at less than half stroke, which avoids the damage that might ensue from excessive compression. It is perfectly practicable to operate the engine at any position of the reverse lever between half stroke and full stroke, without serious injury to the fire. When starting the locomotive from a state of rest, the engineer should always open the cylinder cocks to relieve the cylinders of condensation, and as the starting valve is attached to the cylinder cocks, this movement also admits steam to the low-pressure cylinder and enables the locomotive to start quickly and freely. In case the locomo-

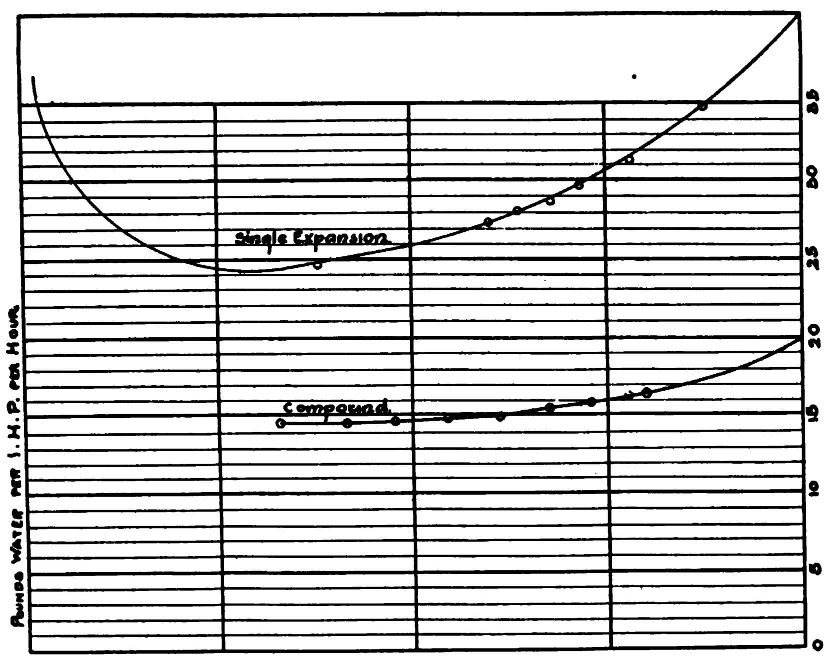
tive is attached to a passenger train and standing in a crowded station, or in some position where it is undesirable to open the cylinder cocks, the engineer should move the cylinder cock lever in position to permit live steam to pass by into the low-pressure cylinder, thus enabling the locomotive to start quickly and uniformly, without any of the jerking motion so common in two-cylinder or cross-compound locomotives. After a few revolutions have been made and the cylinders are free from water caused by condensation or priming, the engineer should move the cylinder cock lever into the central position, causing the engine to work compound entirely. This should be done before the reverse lever is disturbed from its full gear position. The reverse lever should never be "hooked up," thereby shortening the travel of the valve, until after the cylinder cock lever has been placed in the central position. It is often necessary to open the cylinder cocks when at full speed, to allow water to escape from the cylinders, especially when the engineer is what is commonly called a "high-water" man, and in such case no disadvantage is experienced and the reverse lever need not be disturbed. The starting device should not be used for any purpose other than the "starting" of the train. After the train is in motion it should not be used. Cases have been observed where the engineers use it all the time and have the reverse lever "hooked up" in the top notch (half stroke), in consequence of which the locomotive will slow down to a low speed whilst burning an excessive amount of coal. Such running must result in general dissatisfaction.

The starting device is useful in emergencies, as, for instance, when stalling with a heavy train on a grade, if live steam is admitted to the low-pressure cylinder sufficient additional power is obtained to start the train and take it over the grade. This should be resorted to only in emergencies, and allowance should be made for the extra repairs caused by frequent cases of this kind.

On account of the very mild exhaust, the fireman should carry the fire as light as possible. A little practice will enable him to judge how to get along with the least amount of fuel.

The following diagram (Fig. 12) shows the difference in the amount of water required to do the work at various points of

cut-off in compound and single-expansion locomotives. The upper line shows the rate of water consumption per horse-power developed for several points of cut-off in single-expansion locomotives, whilst the lower line shows the same for compound locomotives. It will be observed that the most economical point of cut-off is about one-quarter stroke on the single-expansion locomotive, and about five-eighths stroke on the compound locomotive. It is also noticeable that the water-rate per horse-power varies very little on the compound locomotive when the reverse lever is moved towards full gear or longer cut-off, but in the single-expansion engine it increases rapidly, causing engineers to remark that they cannot "drop her a notch" on account of "getting away with the water." This does not occur with the compound locomotive when the reverse lever is moved forward towards full gear, and no engineer should open the pass-by valve, admitting live steam to the low-pressure cylinder, until the last notch has been used on the quadrant and the engine is about to stall.



POINT OF CUT-OFF.
FIG. 12.

It is also desirable to move the reverse forward a notch before the locomotive slows down too much, as it is better to preserve the momentum of the train than to slow down and again have the trouble of accelerating. In this way both coal and water are wasted. If these instructions are observed the locomotive will work satisfactorily.

REPAIRS.

On account of the great similarity to single-expansion locomotives, mechanics familiar with the latter have no difficulty in understanding these compound locomotives. There is no new element of repairs introduced,—no complicated starting or reducing valves, such as are common to other systems of compound locomotives.

The cross-heads, when badly worn, may, in a short time, be retinned by any coppersmith; in fact, an ordinary laborer can be taught this in a few days. The cross-head is heated warm enough to melt solder, and is then cleaned and wiped with solder, using dilute muriatic acid, such as tinsmiths use in soldering. Block tin is then poured against the surfaces so prepared, to which it adheres. A piece of iron placed alongside the cross-head can be used to regulate the thickness.

The cross-head is then put on a planer to true it up, care being used not to let the tool "dig in" and tear off the tin.

The pistons are treated the same as in ordinary single-expansion engines. The packing-rings in the low-pressure cylinder require renewal more frequently than those in high-pressure cylinders. It is also more difficult in compound cylinders to detect faulty packing-rings, and they are sometimes noticed only by the locomotive failing in steam and in not making time on the road.

The piston-valves should last a long time if properly lubricated, but when the bushing (Fig. 4) and valve (Fig. 5) are worn enough to require attention, the bushing should be bored out and new rings put in the valve; very often it is not necessary to bore the bushings, merely to put new packing-rings in the valve.

After the bushings (Fig. 4) have been bored several times, larger valves may be fitted to them so as to have as little play

as possible. A very convenient type of boring bar for boring out the bushings has been designed, by which the work can be done without taking down the back head of the steam-chest. It is possible with this tool to bore out the bushings in less time than required to face a valve seat on a single-expansion locomotive.

When putting new bushings in the steam-chests, the device shown in Fig. 13 may be used, which gives the required power and is slow enough to permit the bushing to accommodate itself to the cylinder casting.

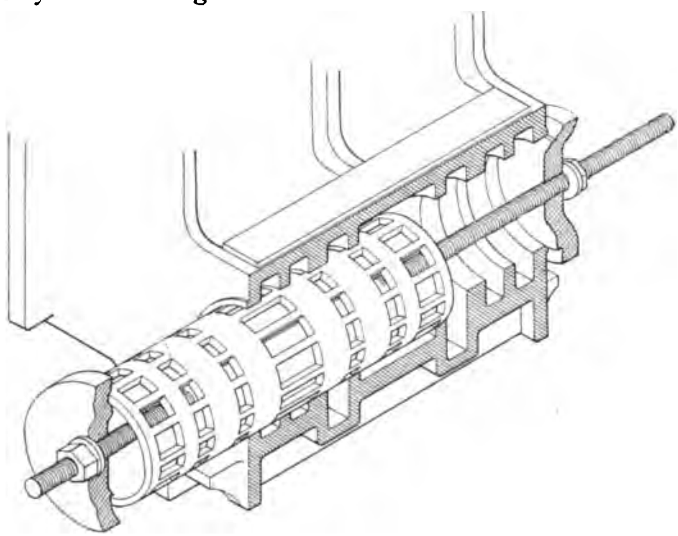


FIG 13.

When extracting old bushings, it is best to split them with a narrow cape chisel—they are only fit for scrap when removed, and can be much more quickly removed this way than to attempt to draw them out with draw screws.

Enough attention should be given the starting valves to insure their moving in harmony with each other. Engineers sometimes strain the cylinder cock shaft, which causes one starting valve to open and the other to remain shut; this causes the exhaust to beat unevenly, and the engineer is apt to complain that the valves are out of square. Before altering the valve motion on these

engines, make sure that the starting valves open and close simultaneously, and examine low-pressure pistons and piston valve for broken packing-rings. In one case an engineer ran his locomotive two days without any piston-head on one of the low-pressure pistons, and even then could not tell what was the matter, only that the locomotive sounded "lame" and did not make good time with the train. Men were put to work to locate the trouble, and found it, to the great surprise of the engineer.

ADDENDA.

It is not claimed for compound locomotives that a heavier train can be hauled at a given speed than with a single-expansion locomotive of similar weight and class. No locomotive can haul more than its adhesion will allow; but the compound will, at very slow speed on heavy grades, keep a train moving where a single-expansion locomotive will slip and stall. This is due to the pressure on the crank-pins of the compound being more uniform throughout the stroke than is the case with the single-expansion locomotive.

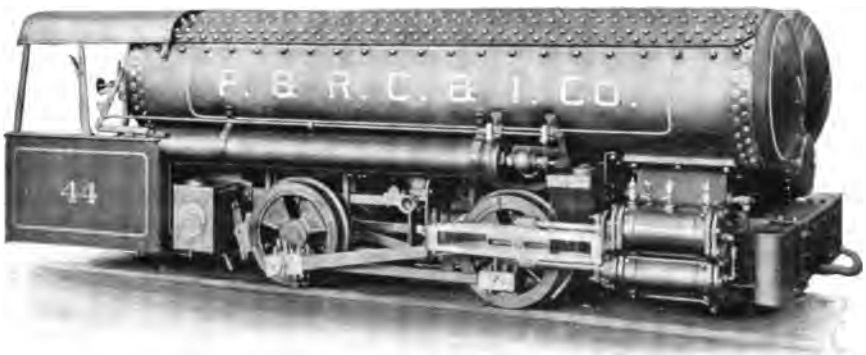
The principal object in compounding locomotives is to effect fuel economy, and this economy is obtained,—

1. By the consumption of a smaller quantity of steam in the cylinders than is necessary for a single-expansion locomotive doing the same work.

2. The amount of water evaporated in doing the same work being less in the compound, a slower rate of combustion combined with a mild exhaust produces a higher efficiency from the coal burned.

In a stationary engine, which does not produce its own steam supply, it is of course proper to measure its efficiency solely by its economical consumption of steam. In an engine of this description the boilers are fired independently, and the draft is formed from causes entirely separate and beyond the control of the escape of steam from the cylinders; hence, any economy shown by the boilers must of necessity be separate and distinct from that which may be effected by the engine itself. In a locomotive, however, the amount of work depends entirely upon the

weight on the driving-wheels, the cylinder dimensions being proportioned to this weight; and whether the locomotive is compound or single-expansion, no larger boiler can be provided, after allowing for the wheels, frames, and other mechanism, than this weight permits. Therefore, the heating surfaces and grate area are practically the same in both types, and the evaporative efficiency of both locomotives is determined by the action of the exhaust, which must be of sufficient intensity in both cases to generate the amount of steam necessary for utilizing, to the best advantage, the weight on the driving-wheels. This is is a feature



COMPRESSED AIR LOCOMOTIVE, PHILADELPHIA & READING COAL & IRON CO.

that does not appear in a stationary engine, so that the compound locomotive cannot be judged by stationary standards, and the only true comparison to be made is between locomotives of similar construction and weight, equipped in one case with compound and in the other with single-expansion cylinders.

One of the legitimate advantages of the compound system is that, owing to the better utilization of the steam, less demand is made upon the boiler, which enables sufficient steam-pressure to be maintained with the mild exhaust, due to the low tension of the steam when exhausted from the cylinders. This milder exhaust does not tear the fire, nor carry unconsumed fuel through the flues into the smoke-box and thence out of the smoke-stack, but is sufficient to maintain the necessary rate of combustion in

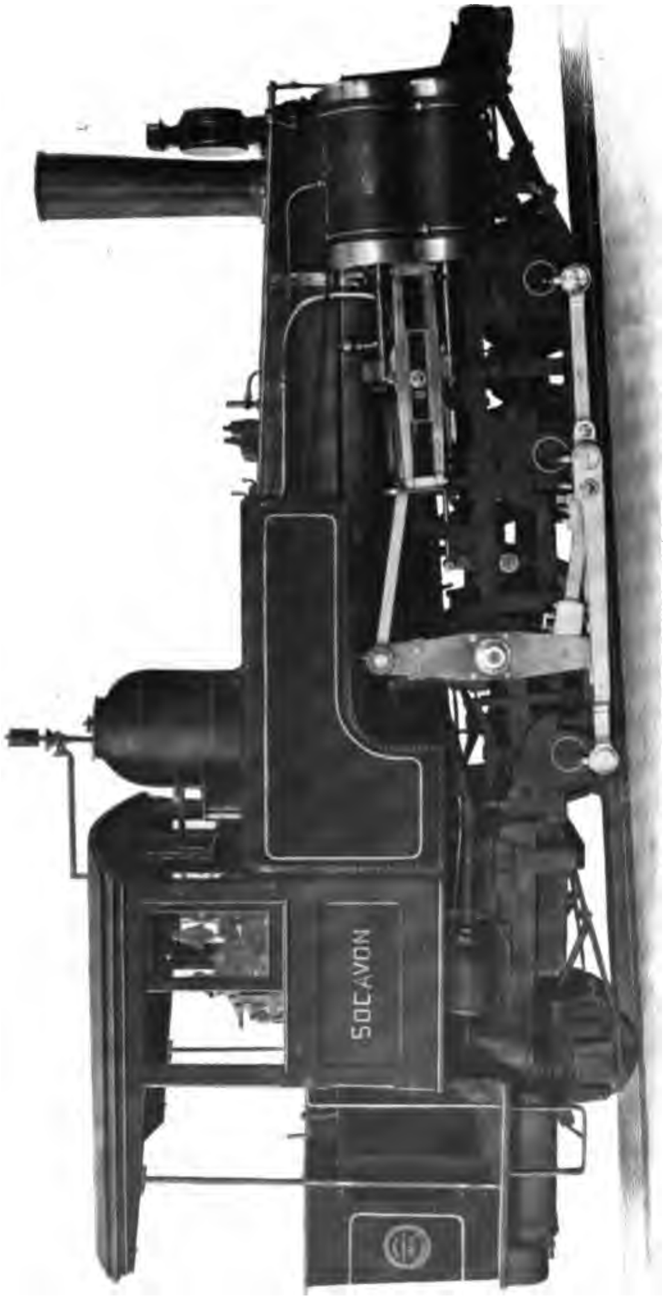
the fire-box with a decreased velocity of the products of combustion through the flues.

The heating surfaces of a boiler absorb heat units from the fire and deliver them to the water at a certain rate. If the rate at which the products of combustion are carried away exceeds the capacity of the heating surfaces to absorb and deliver the heat to the water in the boiler, there is a continual waste that can be overcome only by reducing the velocity of the products of combustion passing through the tubes. This is effected by the com-

ENCLOSED SWITCHING LOCOMOTIVE.

pound principle. It gives, therefore, not only the economy due to a smaller consumption of water for the same work, but the additional economy due to slower combustion. It is obvious that these two sources of economy are interdependent.

The improved action of the boiler can be obtained only by the use of the compound principle, while the use of the compound principle enables the locomotive to develop its full efficiency under conditions which in a single-expansion locomotive would require a boiler of capacity so large as to be out of the question under the circumstances usually governing locomotive construction. It is therefore evident that where both locomotives are



RACK AND ADHESION LOCOMOTIVE, CIA. MINERA DE PEÑOLES.

exact duplicates in all their parts, excepting the cylinders, the improved action of the boiler is due entirely to the compound principle, and the percentage of economy should be based upon the total saving in fuel consumption, and not upon the water consumption, as in stationary practice.

For the benefit of those who may test these locomotives, the following method is presented of determining the water rate per horse-power from an indicator diagram:

S = Stroke in inches.
C = Per cent. of stroke completed at cut-off.
P = Pressure of steam at cut-off, taken from zero.
Wp = Weight per cubic foot of steam at P pressure.
H = Per cent. of stroke uncompleted at compression.
Q = Pressure of steam at compression, taken from zero.
Wq = Weight per cubic foot of steam at Q Pressure.
E = Per cent. of clearance in H.-P. cylinders.
A = Area of H.-P. cylinders.
P = M.E.P. of H.-P. cylinders.
a = Area of L.-P. cylinders.
K = M.E.P. of L.-P. cylinders.
N = Number of revolutions per minute.
r = Ratio $\frac{a}{A}$; hence, $a = A \times r$.

All calculations are made on the basis of the high-pressure cylinder doing the work of both cylinders.

The volume of the piston displacement is $A\ S$, and the volume at cut-off is $A\ S\ C$, since C is the proportion of stroke completed at cut-off. The volume of N revolutions would be $A\ N\ S\ C$. As there are two strokes of the piston for each revolution, and there is an engine on each side of the locomotive, assuming that both engines are doing exactly the same work, there would be four strokes per revolution; hence $4\ A\ N\ S\ C$ is the volume of piston displacement at cut-off for one revolution. Since the clearance-space is expressed in percentage of the piston displacement of one stroke, and which space is filled at each stroke, the volume of the clearance-space for one revolution would be $4\ A\ N\ S\ E$. The sum of these two quantities divided by 1728 will give the volume in cubic feet. The indicator-card gives the pressure at cut-off, and a reference to the steam-table will give the weight of steam at that pressure; hence, the amount of steam

AMERICAN TYPE LOCOMOTIVE FRENCH STATE RAILWAYS.

used per revolution becomes $\left(\frac{4\,A\,N\,S\,C + 4\,A\,N\,S\,E}{1728}\right) Wp$. But there is a certain amount of steam saved at compression, and the volume at this point would be $\left(\frac{4\,A\,N\,S\,H + 4\,A\,N\,S\,E}{1728}\right) Wq$. The volume of the clearance-space being again taken into consideration. Since this steam is saved by compression, it should be deducted from the amount used, and the formula becomes:
$\left(\frac{4\,A\,N\,S\,C + 4\,A\,N\,S\,E}{1728}\right) Wp - \left(\frac{4\,A\,N\,S\,H + 4\,A\,N\,S\,E}{1728}\right) Wq$; or $\frac{4\,A\,N\,S}{1728}\Big((C + E)\,Wp - (H + E)\,Wq\Big)$. The H.-P. equals $\frac{4\,A\,N\,S\,(P + r\,K)}{12 \times 33{,}000}$. Then the water rate per minute would be

$$\frac{\frac{4\,A\,N\,S}{1728}\Big((C + E)\,Wp - (H + E)\,Wq\Big)}{\frac{4\,A\,N\,S\,(P + r\,K)}{12 \times 33{,}000}}, \text{ or } \frac{229.16}{P + r\,K}\Big((C + E)\,Wp - (H + E)\,Wq\Big);$$

and the rate per hour would be $\frac{60 \times 229.16}{P + r\,K}$, or $\frac{13750}{P + r\,K}\Big((C + E)\,Wp - (H + E)\,Wq\Big)$, which formula is to be used.

If it is desired to get the steam at release H.-P., substitute the value of the point R and pressure t, also $S \times R$, respectively, for C, p, and $C \times S$. See Figs. 14 and 15.

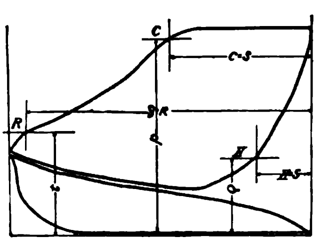


FIG. 14.

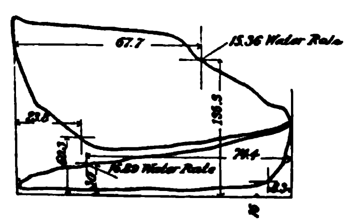


FIG. 15.

M.E.P. H.-P. cylinder	87 pounds	Clearance	.08
M.E.P. L.-P. cylinder	32 pounds	Ratio	2.87 to 1
M.E.P. referred to H.-P. cylinder			178.84
M.E.P. referred to L.-P. cylinder			62.31

$$178.84 = P + r\,K$$

$$62.31 = K + \frac{P}{r}$$

$$\begin{array}{r} 135.3 \\ 14.7 \\ \hline 150.0 \end{array} = .3376 \text{ pound per cubic foot of steam at cut-off H.-P. cylinder.}$$

$$\begin{array}{r} 60.3 \\ 14.7 \\ \hline 75.0 \end{array} = .1756 \text{ pound per cubic foot of steam at compression H.-P. cylinder.}$$

$$\begin{array}{r} 30. \\ 14.7 \\ \hline 44.7 \end{array} = .1079 \text{ pound per cubic foot of steam at point on L.-P. expansion line.}$$

$$\begin{array}{r} 16. \\ 14.7 \\ \hline 30.7 \end{array} = .0758 \text{ pound per cubic foot of steam at compression L.-P. cylinder.}$$

$$\frac{13750}{178.84} = 76.88 \qquad \frac{13750}{62.31} = 220.67$$

$$(.677 + .08) \times .3376 = .2556 \qquad (.238 + .08) \times .1756 = .0558$$

$$\begin{array}{r} .2556 \\ .0558 \\ \hline .1998 \end{array}$$

$.1998 \times 76.88 = 15.36$ pounds steam at cut-off H.-P. cylinder.

$$(.744 + .08) \times .1079 = .0889 \qquad (.083 + .08) \times .0758 = .0124$$

$$\begin{array}{r} .0889 \\ .0124 \\ \hline .0765 \end{array}$$

$.0765 \times 220.67 = 16.89$ pounds steam at point on expansion line L.-P. cylinder.

RACK LOCOMOTIVE, S. ELLERO AND VALLOMBROSA.

The following method of combining indicator diagrams, devised by Mr. George H. Barrus, is given also, and is generally accepted by all engineers as the correct method.

METHOD OF COMBINING CARDS.

(FURNISHED BY MR. GEORGE H. BARRUS.)

The method employed corresponds to that given in Rankine's book on the steam-engine, but is here given more in detail. This method will be clearly understood if it is remembered that every point in the expansion line of the L.-P. card of the combined diagram should correctly represent the pressure and volume of the steam at the corresponding point of the stroke of the low-pressure piston, the volume being measured from the clearance line of that cylinder. Refering to Fig. 16, the H.-P. diagram is an exact copy of the original except in point of scale.

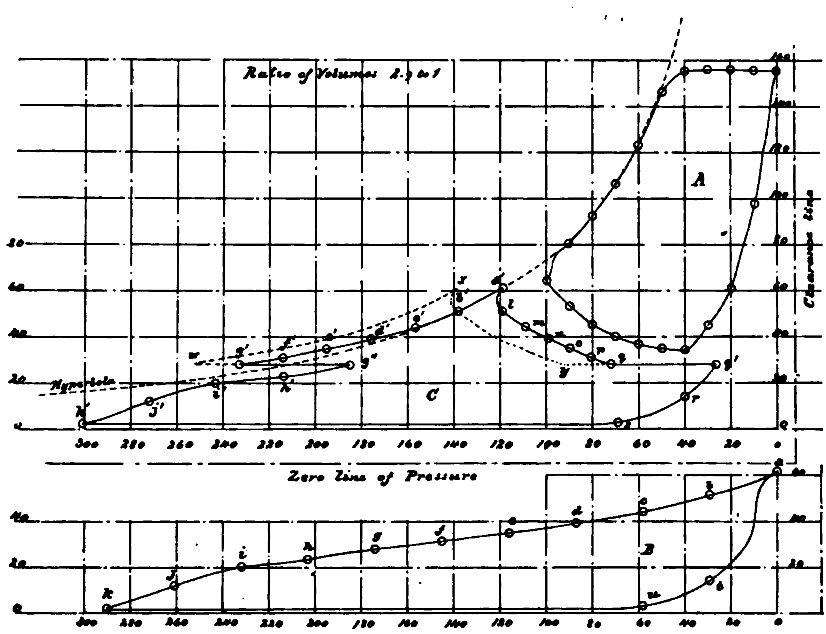


FIG. 16.

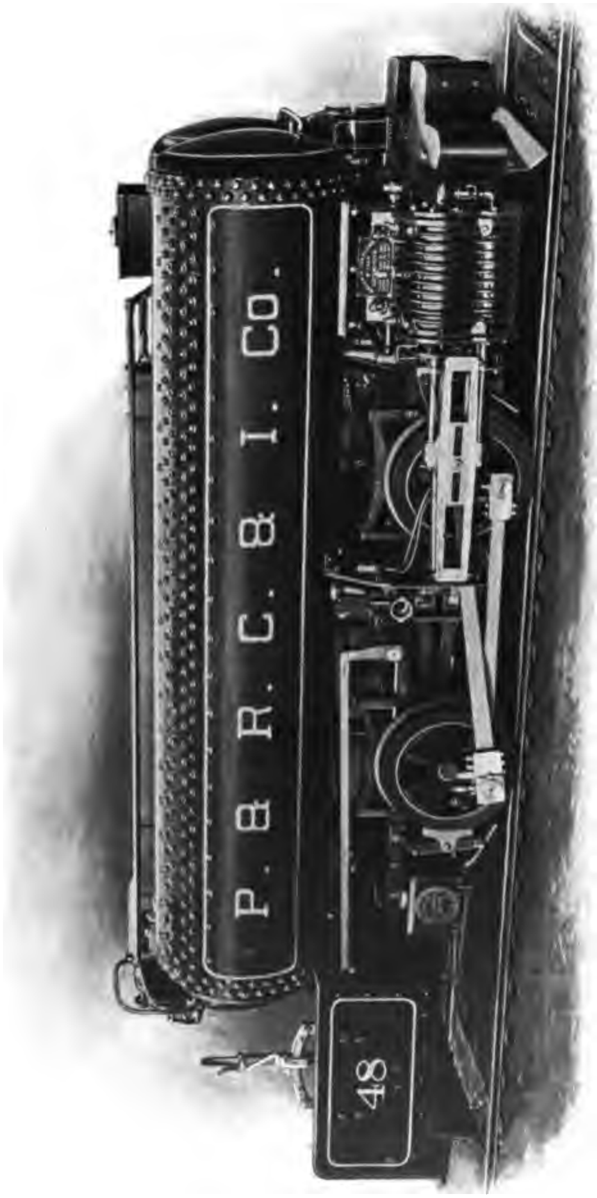
TEN-WHEEL LOCOMOTIVE CANADIAN PACIFIC RAILWAY.

The L.-P. diagram at the bottom of Fig. 16 is also an exact copy of the original on the same scale of pressure as the H.-P. diagram, though of different length; this last having the same ratio to the length of the H.-P. diagram as the area of the piston of the L.-P. cylinder has to the area of that of the high; in this case 2.9. The length of the H.-P. diagram on the scale of the chart is 100, as indicated, and of the L.-P. diagram 290.

To draw the L.-P. portion of the diagram, it may be divided into, say, ten equal parts, and the points of the division marked *a, b, c, d,* and *e*. The various points on the combined L.-P. dia-

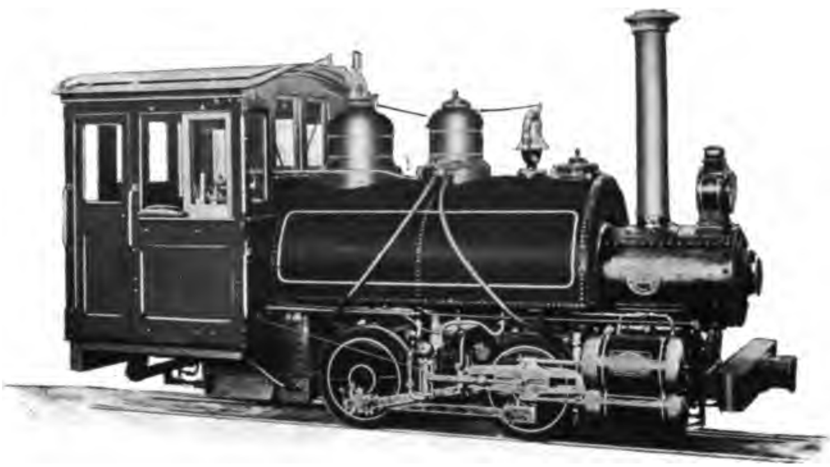
FOUR-COUPLED SIX-WHEEL TANK LOCOMOTIVE STATE TRANSCAUCASIAN.

gram are located horizontally, so as to mark the various volumes occupied by the steam at the respective points, as already noted. Below the point of cut-off, which is located at .6 of the stroke, or at the point 9, the combined diagram is an exact reproduction of the lower diagram. The points in this portion of the diagram showing volume, that is, the horizontal distances, represent the volumes of the L.-P. cylinders at those points, plus the clearance of the same. The clearance is 6.5 per cent. of the stroke of the L.-P. piston, or is 18.9 points of division on the scale of the chart. The distance, for example, of the point *h* from the clearance line on the combined diagram, will be .7 of 290 + 19, or 203 + 19 = 222, and likewise for the remaining points below the cut-off. The



COMPRESSED AIR LOCOMOTIVE, PHILADELPHIA & READING COAL & IRON CO.

points in the expansion line of the L.-P. combined diagram, above the points of cut-off, lie farther to the left, for the reason that the volume of the steam expanding is not only the apparent volume of that contained in the L.-P .cylinder, but in addition, that of the steam being exhausted from the H.-P. cylinder (the valve being open between the two), and that contained in the clearance space of the same. Take, for instance, the point *a'*, or the initial point of the diagram; the volume here is that of the H.-P. cylinder, the clearance of the H.-P. cylinder, and the clear-



NARROW-GAUGE FOUR-COUPLED TANK LOCOMOTIVE HAWAIIAN AGRICULTURAL CO., LTD.

ance of the L.-P. cylinder. The point *a'* is therefore laid off at a distance of 19 divisions to the left of the end of the H.-P. diagram, or at the division marked 119 on the chart. At the point *b'* the volume of the steam has been increased, corresponding to 1-10 of the L.-P. cylinder, or 29 divisions, but at the same time it has been reduced correspondingly to 1-10 of the H.-P. cylinder, or to 10 divisions, so that the combined effect is to increase the volume 19 divisions to the left of the point *a'*. The remaining points from *b'* to *g'* are laid off successively at distances of 19 divisions. At *g'*,where the valve closes and cuts off communications between the H.-P. and L.-P. cylinders,

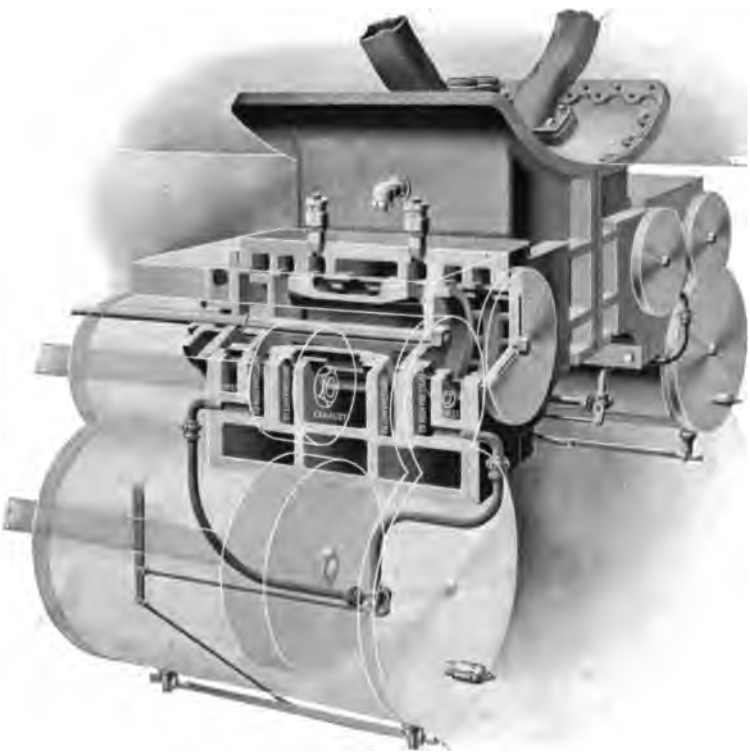
TEN-WHEEL FREIGHT LOCOMOTIVE CHILEAN STATE RAILWAYS.

the volume contracts, and this feature is represented by the horizontal line g' g''. To obtain the remaining points of the combined diagram from a' to q', the various points are laid off, so that the horizontal distances from the expansion line shall be the same as those in the lower diagram. In this way the area of the combined diagram is exactly the same as that of the original diagram. The dotted line x w y shows the position of the combined diagram, supposing the intermediate space within the valve were empty when the H.-P. cylinder exhausted, assuming that the volume of this space is 20 per cent. of the volume of the H.-P. cylinder. In reality this space is not empty, but is always filled with steam somewhat above the pressure at cut-off in L.-P. cylinder.

NARROW-GAUGE LOCOMOTIVE, NORWEGIAN STATE RAILWAY.

SUGGESTIONS FOR RUNNING A VAUCLAIN FOUR-CYLINDER COMPOUND LOCOMOTIVE.

In starting the locomotive with a train, place the reverse lever in full forward position, throw the cylinder-cock lever forward, which operation opens the starting-valve and allows live steam to pass to the low-pressure cylinder. The throttle is then



VIEW SHOWING GENERAL ARRANGEMENT OF CYLINDERS, WITH SECTION THROUGH STEAM CHEST VALVE AND PORTS.

opened, and as soon as possible when the cylinders are free of water and the train is under good headway, the cylinder cocks and starting-valve should be closed. As the economy of a compound locomotive depends largely on its greater range of expan-

sion, the engineer should bear in mind that in order to get the best results he must use his reverse lever. After the starting-valve is closed and as the speed of the train increases, the reverse lever should be hooked back a few notches at a time until the full power of the locomotive is developed. If after moving the reverse lever to the last notch, which cuts off the steam at about half stroke in the high-pressure cylinder, it is found that the locomotive develops more power than is required, the throttle must be partially closed and the flow of steam to the cylinder reduced. On slightly descending grades the steam

RACK LOCOMOTIVE, MANITOU AND PIKES PEAK RAILWAY.

may be throttled very close, allowing just enough in the cylinders to keep the air-valves closed. If the descent is such as to prevent the use of steam, close the throttle and move the reverse lever gradually to the forward notch and move the starting-valve lever to its full backward position. This allows the air to circulate either way through the starting-valve from one side of the piston to the other, relieves the vacuum, and prevents the oil from being blown out of the cylinder. On ascending grades with heavy loads as the speed decreases the reverse lever should be moved forward sufficiently to keep up the required speed. If, after the reverse lever is placed in the full forward notch, the speed still

decreases and there is danger of stalling, the starting-valve may be used, admitting steam to the low-pressure cylinders. This should be done only in cases of emergency and the valve closed as soon as the difficulty is overcome.

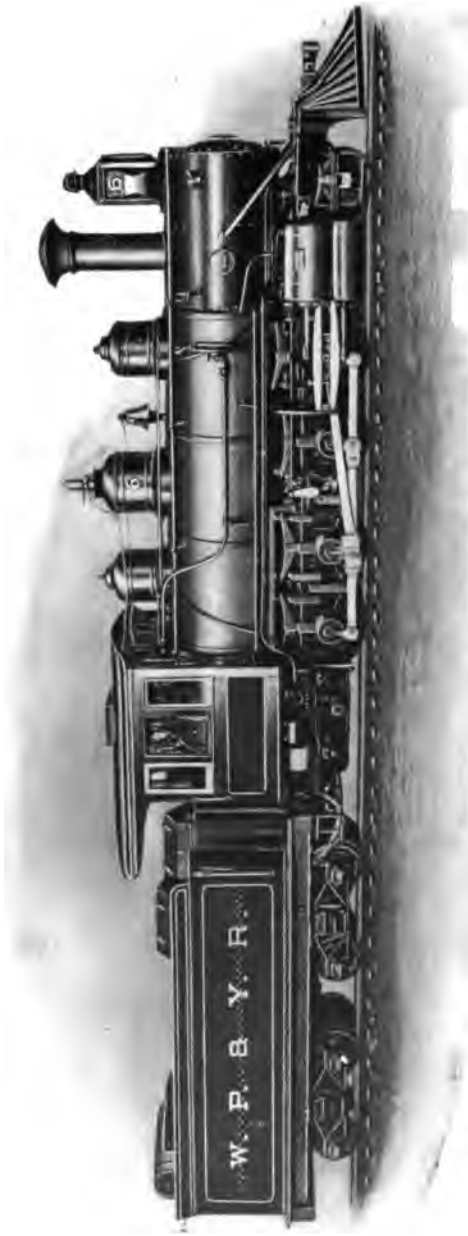
The tractive power of Vauclain four-cylinder compound locomotives may be ascertained by the following formula:

$$\frac{C^2 \times S \times \frac{2}{3} P}{D} + \frac{c^2 \times S \times \frac{1}{4} P}{D} = T, \text{ in which}$$

C=Diameter of high-pressure cylinder in inches.
c=Diameter of low-pressure cylinder in inches.
S=Stroke of piston in inches.
P=Boiler pressure in pounds.
D=Diameter of driving wheels in inches.
T=Tractive power.

The first Vauclain compound locomotive was built in 1889; in the year 1890 three more were built, followed in 1891 by 82, in 1892 by 213, in 1893 by 160, in 1894 by 30, in 1895 by 51, in 1896 by 173, in 1897 by 86, in 1898 by 235, in 1899 by 241, and in 1900 there have been built or orders have been received for 517. Those already shipped are distributed among the various railroad companies as follows:

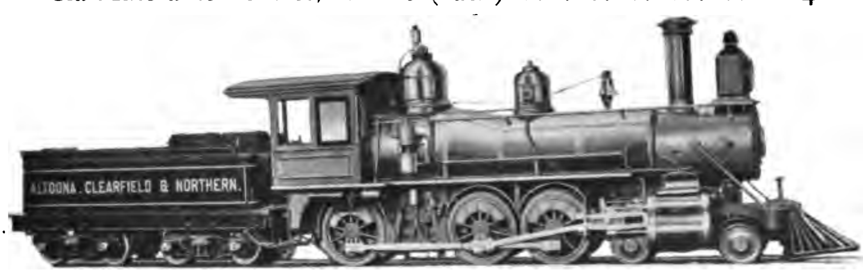
Algoma Central	1
Altoona, Clearfield and Northern	1
Altoona and Phillipsburg Connecting	2
Arizona and South Eastern	1
Atlantic Coast Line	2
Bahia Extension, Brazil	11
Baldwin Locomotive Works, stock	2
Baltimore and Ohio	81
Baltimore and Ohio Southwestern	47
Barranquilla Railway	2
Bavarian State	2
Brazilian Industrial Improvement Co	3
Brooklyn Wharf and Warehouse Co	2
Buffalo, Rochester and Pittsburg	6
Buenos Aires Western	2
Calumet and Hecla	1
Cambria Steel Co	2
Canadian Pacific	34



NARROW-GAUGE CONSOLIDATION LOCOMOTIVE, WHITE PASS AND YUKON.

NARROW-GAUGE MOGUL LOCOMOTIVE, CENTRAL DOMINICAN.

Central Dominican	3
Central of Georgia	3
Central Railroad of Brazil	23
Central Railroad of New Jersey	14
Chicago and Alton	10
Chicago and Erie	2
Chicago and Grand Trunk	1
Chicago and Great Western	5
Chicago and Northwestern	3
Chicago and South Side	45
Chicago, Burlington and Quincy	2
Chicago, Milwaukee and St. Paul	79
Chicago, Rock Island and Pacific	16
Chilean State Railways	4
Chinese Eastern	148
Cia Minera de Peñoles, Mexico (rack)	4



TEN-WHEEL PASSENGER LOCOMOTIVE, ALTOONA CLEARFIELD & NORTHERN RAILROAD.

Cincinnati, Hamilton and Dayton	1
Cincinnati, New Orleans and Texas Pacific	12
Cleveland, Akron and Columbus	2
Columbia University	1
Cornwall and Lebanon	1
Consolidation Coal Co.	1
Delaware, Lackawanna and Western	1

NARROW-GAUGE FOUR-COUPLED DOUBLE-ENDED ENCLOSED LOCOMOTIVE, SAN JOSÉ & ALUM ROCK RAILWAY.

Detroit and Lima Northern	1
Elgin, Joliet and Eastern	1
Engenho Central, Brazil	1
Erie	73
F. C. del Norté	3
F. C. de Merida á Valladolid	1
Fitchburg	7
French State	5
Frick Coke Co.	5
Gordon, Simon James	3
Great Northern	7
Government New South Wales, Australia	2
Grand Trunk	10
Hamilton and Dundas	1

Hawaiian Agricultural Co.	1
Hidalgo Railroad, Mexico	1
Intercolonial Railway of Canada	20
International Construction Co.	1
Interoceanic of Mexico	2
Iowa Central	7
Jacksonville, Tampa and Key West	1
Kentucky Union	1
Lehigh and Lackawanna	2
Lehigh Coal and Navigation Co.	2
Lehigh Valley	64
Leopoldina Railway, Brazil	1
Long Island	15
Longdale Iron Co.	3
Los Angeles Terminal	1
McCloud River	1
Marietta and North Georgia	1
Mexican National	32
Mineral Range	1
Minneapolis, St. Paul and Sault Ste. Marie	1

MOGUL LOCOMOTIVE, BRAZILIAN INDUSTRIAL IMPROVEMENT CO.

Missouri, Kansas and Texas	16
Mogyana Railroad, Brazil	1
Moscow Kazan	2
Moscow-Keif-Voronesh	33
Moscow-Windau-Ribinsk	20
New Orleans and Northeastern	4

NARROW-GAUGE TEN-WHEEL LOCOMOTIVE, MEXICAN NATIONAL RAILROAD.

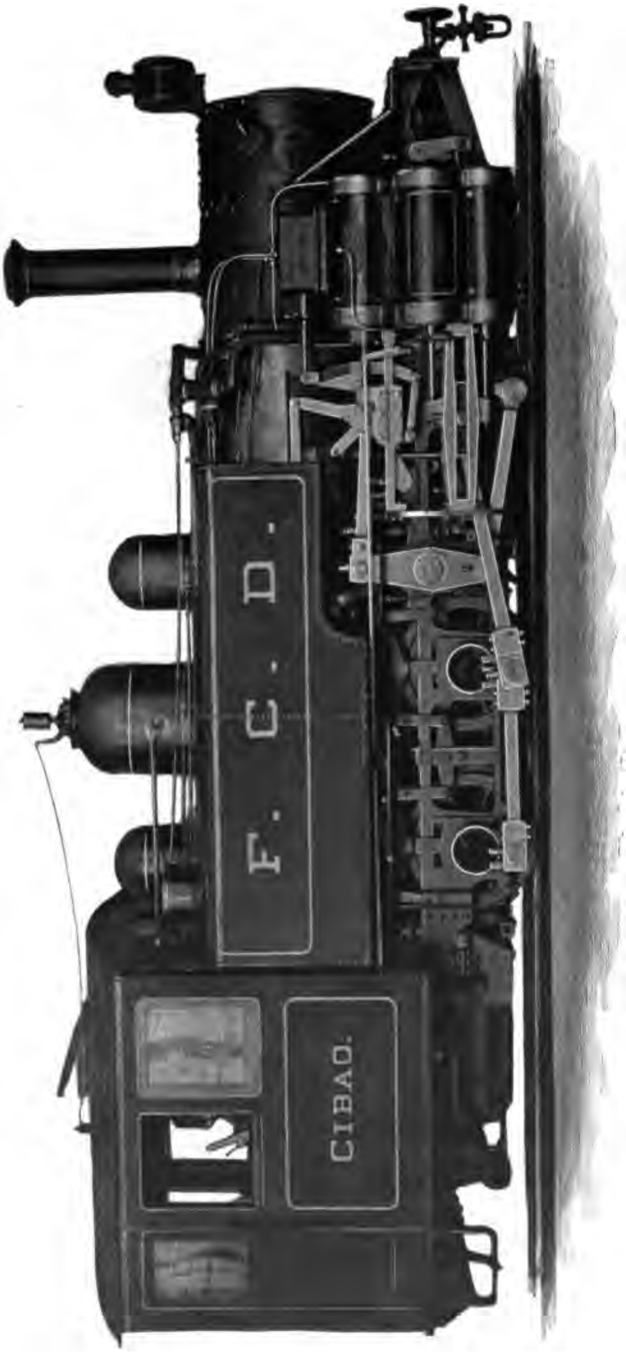
New South Wales	2
New York and New England	12
New York, Chicago and St. Louis	1
New York, Pennsylvania and Ohio	8
New Zealand	4
Norfolk and Southern	3

NARROW-GAUGE TEN-WHEEL LOCOMOTIVE, OESTE DE MINAS RAILWAY, BRAZIL.

Norfolk and Western	46
North Chicago Street Railway	1
Northern Pacific	5
Norwegian State Railways	4
Oeste de Minas, Brazil	22
Ottawa, Arnprior and Parry Sound	28

"AMERICAN" TYPE LOCOMOTIVE, PAULISTA RAILWAY BRAZIL.

Oosoori Railway of Russia	1
Paulista Railway, Brazil	52
Pennsylvania	7



RACK AND ADHESION LOCOMOTIVE, SANTO DOMINGO RAILWAY

Pennsylvania and Northwestern	10
Pernambuco Extension, Brazil	7
Philadelphia and Reading	129
Philadelphia and Reading Coal and Iron Co	4
Pikes Peak (rack)	5
Pittsburg, Cincinnati, Chicago and St. Louis	1
Plymouth Cordage Co	1
Ramul Dumont, Brazil	1
Ramul Ferreo Campineiro, Brazil	2
Richmond and Danville	1
Rio Grande Western	4
Rockaway Valley	1

PLANTATION LOCOMOTIVE, RAMAL DUMONT, BRAZIL.

Rumford Falls and Rangeley Lakes	1
Salinas	1
Sandusky and Columbus Short Line	2
San José and Alum Rock, Hugh Centre	1
Santo Domingo (rack)	1
Sanyo Railway, Japan	7
Seaboard Air Line	2
S. Ellero and Vallombrosa (rack)	1
Sinnemahoning Valley	1
Sormova Co., Ltd., Russia	3
Southeastern Russia	66
Southern	1
State Transcaucasian, Russia	8

FRONT VIEW OF VAUCLAIN COMPOUND LOCOMOTIVE.

St. Louis and San Francisco	5
Texas and Pacific	1
Texas Central	4
Tikuho Railway of Japan	1
Toledo, Ann Arbor and North Michigan	6
Union Pacific	20
Union Terminal of Kansas City	1
United Verde Copper Co.	2
Virginia and Southwestern	6
Victorian Railways, Australia	1
Vladicaucase of Russia	80
Wabash	3
Wellington and Manawatu, New Zealand	4
Western Counties, Nova Scotia	2
Western Maryland	2

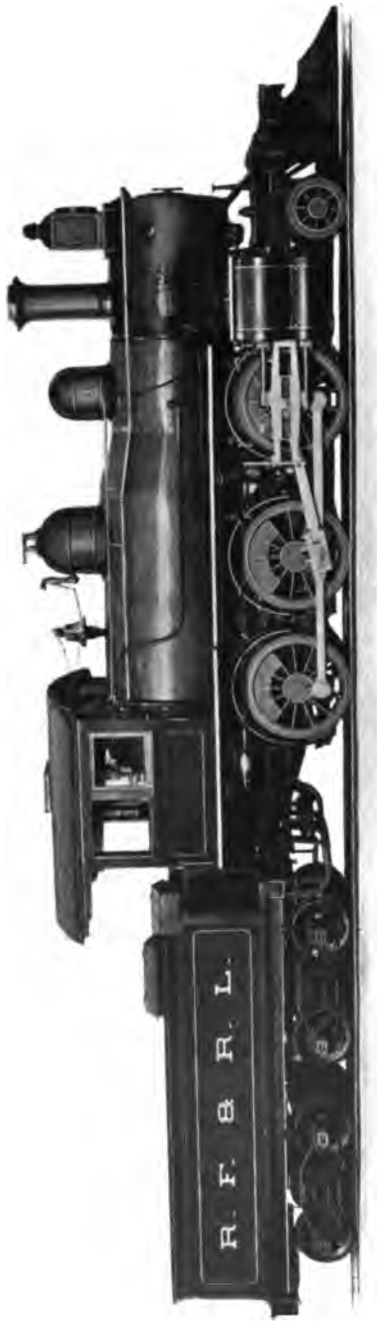
DECAPOD LOCOMOTIVE, STATE TRANSCAUCASIAN RAILWAY OF RUSSIA.

Western New York and Pennsylvania	1
Western Railway of Havana	1
West Virginia Central and Pittsburg	2
White Pass and Yukon	2
Wilmington Street Railway	1

Comparative tests of Vauclain compound and single-expansion locomotives have been made by capable engineers, and usually under the supervision of the locomotive department of the respective lines.

Following is a summary of the general results:

In July, 1891, a test was made in freight service by Mr. John Hickey, Superintendent of Motive Power and Machinery of the Northern Pacific Railroad, the work being under the immediate



MOGUL FREIGHT LOCOMOTIVE, RUMFORD FALLS & RANGELY LAKES RAILROAD

supervision of Mr. O. H. Reynolds, then Mechanical Engineer for the company, of the compound Mogul locomotive No. 587, and a single expansion Mogul No. 584, both being of same dimensions and weight and differing only in the cylinders and boiler pressure.

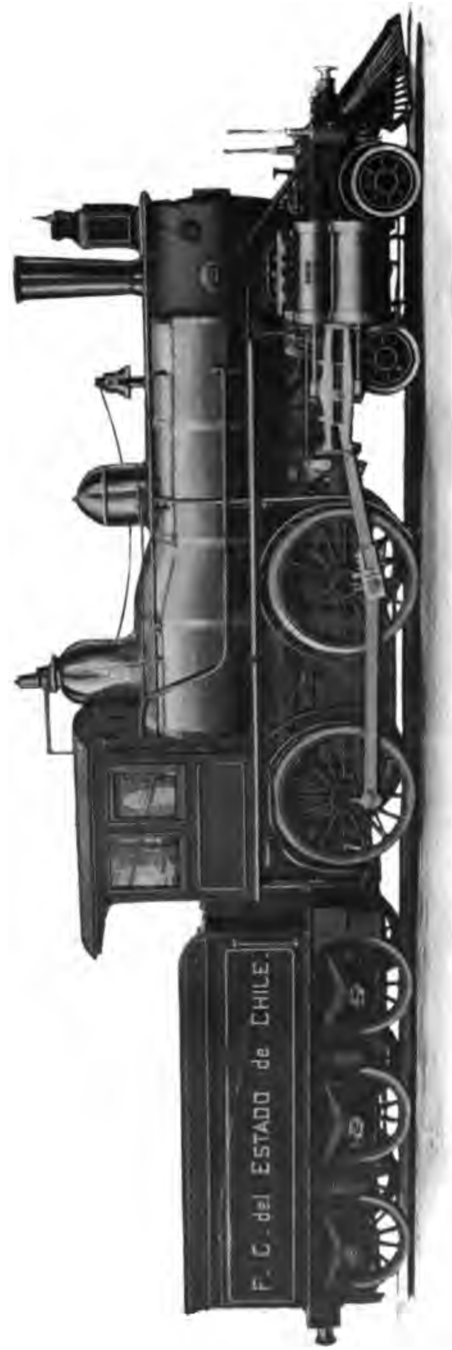
Separate tests were made, (1) with both locomotives carrying 170 pounds of steam pressure, (2) with the compound carrying 170 and the single-expansion carrying 150 pounds pressure, and (3) with both locomotives carrying 150 pounds pressure. The average steam pressure carried for all trips by the compound locomotive was 157.3, and by the single-expansion locomotive was 151.9 pounds. The course was between Staples, Minnesota, and Fargo, Dakota, a distance of 108.7 miles. The trains were

NARROW-GAUGE AMERICAN TYPE LOCOMOTIVE, F. C. D. MERIDA À VALLADOLID.

selected to give each locomotive as nearly the same weight as possible.

Five trips were run with both locomotives carrying 170 pounds of steam, the average result showing a saving in fuel of 28 per cent. in favor of the compound locomotive. On one trip where the compound locomotive was loaded to its most economical limit, a saving of 53.5 per cent. was made.

Four trips were run with the single-expansion locomotive carrying 150 pounds of steam and the compound carrying 170 pounds, the average result showing a saving of 20.9 per cent. in favor of the compound locomotive. One trip was run with both locomotives carrying 150 pounds of steam, which showed



AMERICAN TYPE LOCOMOTIVE CHILEAN STATE RAILWAYS.

a saving of 18.3 per cent. in favor of the compound locomotive.

The general average of the ten trips gave a total saving in favor of the compound locomotive of 22.2 per cent. in fuel and 11.27 per cent. in water evaporated per pound of coal. The waste gases in the smoke-box of the single-expansion locomotive reached a temperature of 878 deg., while the highest registered by the compound was 590 deg. Fahrenheit.

The highest smoke-box vacuum in the single-expansion loco-

NARROW-GAUGE LOCOMOTIVE, RAMAL FERREO CAMPINEIRO, BRAZIL.

motive was 6 ounces or about 10 inches, and in the compound 4 ounces or about 6¾ inches.

In August and September, 1891, a test was made in freight service by Mr. Allen Vail, General Master Mechanic of the Western New York and Pennsylvania Railroad, of the compound consolidation locomotive No. 175, and single-expansion consolidation No. 169, both locomotives being identical except the cylinders.

The tests were made with the compound locomotive carrying 170 pounds steam pressure, and the single-expansion locomotive carrying 150 pounds. The average pressure carried for all trips by the compound was 166 pounds, and by the single-expansion 147.7 pounds. The course was between Buffalo and Olean, N. Y., a distance of 70 miles. Three round trips were run, with an average increase in favor of the compound locomotive of 36.2

per cent. in weight of train hauled per pound of coal, and of 17.9 per cent. in water evaporated per pound of coal.

The average temperature of the smoke-box gases was 690 deg. in the single-expansion locomotive, and 630 deg. in the compound.

The average smoke-box vacuum in the single-expansion locomotive was 6.4 inches, and in the compound 2.9 inches.

TEN-WHEEL PASSENGER LOCOMOTIVE, MISSOURI, KANSAS & TEXAS RAILWAY.

In January, 1892, a test was made in freight service by Mr. David Holtz, Master of Machinery of the Western Maryland Railroad, of compound consolidation locomotive No. 45, and a single-expansion consolidation locomotive No. 43, of similar size and dimensions with the exception of the cylinders.

The test was made on a mountain grade 10 miles in length with a total ascent of 1000 feet. At several points the grade reaches 105.6 feet per mile, with numerous sharp curves.

A single trip was made with each locomotive under similar conditions with the same train, the single-expansion locomotive carrying 147 pounds steam pressure, and the compound carrying 175 pounds.

The saving in fuel was 44.9 per cent. in favor of the compound locomotive. Quite a saving was also noted in the consumption of water.

In January, 1892, several tests were made, both in passenger and freight service, by Mr. R. H. Soule, Superintendent of Motive Power of the Norfolk and Western Railroad,—the work being under the supervision of Mr. George R. Henderson, Chief

Draughtsman,—of the ten-wheel compound locomotive No. 82. The test was made and the data of the performance noted for comparison with tests which had previously been made with similar single-expansion locomotives in the same service.

MOGUL FREIGHT LOCOMOTIVE, NORTHERN PACIFIC RAILROAD.

The average steam pressure carried by the compound locomotive was 181 pounds, and that carried by the single-expansion locomotives with which it was compared was 139 pounds. The course over which the run was made in passenger service was between Roanoke and Bristol, a distance of 150 miles, and that for freight service between West Roanoke and Radford, a dis-

SIX-COUPLED TANK LOCOMOTIVE CHINESE EASTERN RAILWAY

tance of 41.6 miles. Four round trips were made with a passenger train and two round trips with freight. Comparing the general average with that of the single-expansion locomotives, it was found that the compound showed a saving in fuel of nearly 38 per cent. per ton per mile, with a corresponding saving in water.

NARROW-GAUGE MOGUL FREIGHT LOCOMOTIVE TIKUHO RAILWAY, JAPAN.

Average smoke-box vacuum was in the compound 2¼ inches, and in the single-expansion 5 inches.

In 1892 a test was made on the Chicago, Milwaukee and St. Paul Railroad, by a committee appointed by the Master Mechanics' Association, of compound locomotive No. 827, and the single-expansion locomotive No. 822, of precisely the same construction excepting the cylinders. The tests extended over a period of nearly two months, sixty complete single trips being made, the locomotives carrying 180 and 200 pounds pressure of steam. The route selected was from Milwaukee to Portage, a distance of 91 miles.

The average economy of the compound locomotive was placed at 16.9 per cent. in fuel and 14.1 per cent. in water.

In September and October, 1892, a test was made in passenger service by Mr. James Meehan, Superintendent of Motive Power and Machinery of the Cincinnati, New Orleans and Texas Pacific Railway, of the ten-wheel compound locomotive No. 604, and a single expansion locomotive of the same type, No. 531.

The tests were made with both limited and accommodation trains, the compound locomotive carrying 180 pounds pressure

of steam, and the single expansion 140 pounds. The average steam pressure shown by the indicator cards was for the compound 173.3 pounds, and for the single-expansion 133.3 pounds.

FAST PASSENGER LOCOMOTIVE, PHILADELPHIA & READING RAILROAD.

The distance run was 93.3 miles. Ten trips were made with each locomotive. The average results showed a total saving in consumption of fuel in favor of the compound locomotive of 35½ per cent. in pounds of coal per car mile, but as the compound locomotive had a somewhat larger amount of heating surface, it was thought best to place the gain at 25 per cent., in order to be sure and on the safe side.

In November, 1893, a series of tests was made in freight service by Mr. Chas. M. Jacobs, Consulting Engineer of the Long Island Railroad, and his assistant, Mr. J. V. Davies, of the ten-wheel freight locomotive No. 145 and the ten-wheel single-expansion locomotive No. 138. It was arranged in this test to run three consecutive trips with each locomotive with a train of twenty loaded cars set apart for the purpose, in order that each locomotive should do the same work under the same conditions. The steam pressure carried by the compound locomotive was 180 pounds and by the single-expansion locomotive 145 pounds.

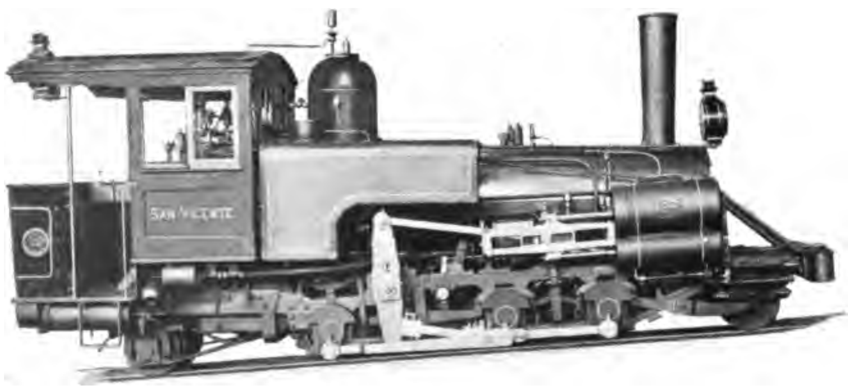
The average steam pressure was, for the compound, 166.7 pounds, and for the single-expansion 126 pounds.

The course was between Hempstead Crossing and Ronkon-

koma, and the train was hauled the round trip twice, making a distance of 113.78 miles.

The general average of these trips showed an economy in fuel of 37.2 per cent., and in water of 10.7 per cent., per car mile, in favor of the compound locomotive.

In December, 1893, and January, 1894, a series of tests was made in passenger service by Mr. L. B. Paxson, Superintendent of Motive Power and Rolling Equipment of the Philadelphia and Reading Railroad, of the compound "Columbia" type locomotive No. 694, and the single-expansion American type locomotive No. 1016.



RACK AND ADHESION LOCOMOTIVE, CIA MINERA DE PEÑOLES, MEXICO.

These tests were conducted (1) to determine the difference of economy of two locomotives and (2) to ascertain if it were possible to use buckwheat or pea coal in high-speed passenger service. Separate tests were made with the locomotives burning egg, pea, and buckwheat coal.

The average steam pressure for the compound was 169.6 pounds, and for the single-expansion 152.9 pounds.

The course was between Camden and Atlantic City, a distance of 55.5 miles.

The results showed that when both locomotives burned egg coal, a saving was made in favor of the compound of 26.9 per cent. When both locomotives burned pea coal the saving in

favor of the compound was 27.3 per cent., and a comparison between the single-expansion locomotive burning egg coal and the compound burning pea coal still showed a saving of 6.9 per cent. in actual weight; but when the difference of cost is considered the saving would be 68.6 per cent. in favor of the compound. It was demonstrated by these tests that pea coal could be satisfactorily used on high-speed passenger service in compound locomotives only, and also that the compound locomotive would do better with pea coal as fuel than the single-expansion locomotive with egg coal.

ATLANTIC TYPE LOCOMOTIVE, CHICAGO BURLINGTON & QUINCY RAILROAD.

In August, 1894, a test was made in freight and passenger service by Mr. J. E. Fulton, Locomotive Superintendent of the Wellington and Manawatu Railway (a narrow-gauge road in New Zealand), of the ten-wheeled compound passenger locomotive No. 14, shown by the illustration on page 148, and the compound consolidation freight locomotive No. 13, the latter in competition with the single-expansion consolidation locomotive No. 12, of similar weight and dimensions.

The crucial test was on a section of the road where a grade of 1 to 100 occurred. This grade was three miles in length, and the compound ran it easily with 83 cars or 350 tons, exclusive of its own weight of 56 tons, at a rate of 6 miles an hour; the usual load for the company's best locomotives of the single-expansion type on this grade being 45 cars or 250 tons.

The result of the test showed a saving in fuel with the compound locomotive of exactly 25 per cent., and the trip was made in quicker time than with the single-expansion.

In April, 1894, a series of tests was made on the Central Railroad of New Jersey, in passenger service, of the compound locomotive No. 450 of the American type, and the single-expansion passenger locomotive No. 455, of similar dimensions.

These tests were conducted by Mr. Russell E. Taylor, M. E., Mr. Chas. C. Kenyon, M. E., and Mr. Edward D. Mathey, M. E., a committee from Stevens Institute of Technology, the object being to ascertain comparatively (1) the evaporation from and at 212 deg. Fahrenheit per pound of coal, (2) the water per hour per horse-power, (3) the coal used per ton of total train mile, and (4) the action of the engines under various conditions.

The course was between Jersey City and Wayne Junction, a distance of 85.1 miles.

SUBURBAN LOCOMOTIVE, LONG ISLAND RAILROAD.

Two round trips were made with each locomotive. The average boiler pressure carried was for the compound 164.9 pounds, and for the single-expansion 157.5 pounds.

The general results obtained show a percentage in favor of the compound locomotive as follows:

In coal consumed during test	19.86 per cent.
In water evaporated from and at 212° per pound of coal on run	18.7 per cent.
In rate of combustion per sq. ft. of grate per hour during run	20.05 per cent.
In tons of train hauled per mile per pound of coal	15.85 per cent.

The record of one ten-wheel compound and nine single-expansion locomotives of the same type, differing only in the construction of the cylinders, taken from the monthly performance sheets issued by Mr. John Mackenzie, Superintendent of Motive Power of the New York, Chicago and St. Louis Railroad, for nine months, from November, 1892, to July, 1893, gives an average consumption of fuel per mile run for the compound locomotive of 3.1 pounds, and for the single-expansion locomotive 4 pounds, making a total saving in favor of the compound locomotive of 22.5 per cent.

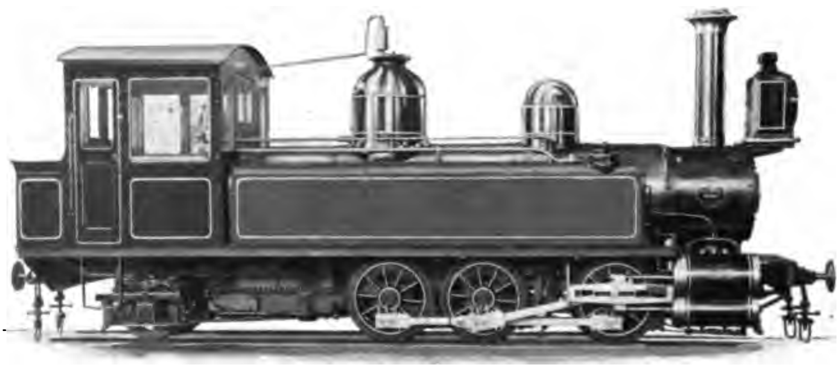
ENCLOSED MOTOR, SALINAS RAILWAY.

In October, 1896, a test was made in freight service, under the direction of Mr. John Hickey, Superintendent M. P. & R. S. of the Northern Pacific Railroad, and under the immediate supervision of Mr. W. B. Norton, Road Foreman of Engines, of a compound consolidation locomotive, No. 488, and a single-expansion consolidation locomotive, No. 492.

As originally built these locomotives were of the same size and general design, the single-expansion cylinders of No. 488 having been subsequently replaced by compound cylinders.

The test was made on the portion of the Northern Pacific Line between Leslie and the summit of the Cascade Mountains, a distance of 16.1 miles, on an average grade of 116 feet per mile.

Out of a number of trips run, three were selected as having all the conditions comparatively equal. These show an average consumption of coal by the compound locomotive of 2976 lbs., and by the single-expansion locomotive of 5521 lbs. The average water evaporation by the compound was 2622 gallons, and by the single-expansion 3759 gallons. The average load



NARROW-GAUGE SIX-COUPLED TANK LOCOMOTIVE, STATE TRANSCAUCASIAN RAILWAY OF RUSSIA.

was 435 tons hauled by the compound and 430 tons hauled by the single-expansion.

The results show a saving in favor of the compound locomotive of forty-six per cent. in the consumption of fuel, and thirty per cent. in the evaporation.

The following table gives the actual running time for one trip made by locomotive No. 1028, with a train of five cars, July 1, 1898, on the Atlantic City Division of the Philadelphia and Reading Railway.

The locomotive is illustrated by the cut of No. 1027, on page 197, which is of same type and dimensions. It will be noted that a single mile was made in 41 seconds, which indicates a speed of 87.8 miles per hour. An average speed of 81.8 miles

per hour was maintained between mile-posts 48 and 3, a distance of 45 miles. This includes some of the heaviest grades on the division. For 36 miles, or from mile-post 39 to mile-post 3, the distance was covered at an average speed of 82.8 miles per hour.

Mile-Posts.	Time. H.	M.	S.	Seconds per Mile.	Mile-Posts.	Time. H.	M.	S.	Seconds per Mile.
Camden	3	50	00	00	27	4	14	55	42
55	3	52	29	149	26	4	15	37	42
54	3	53	44	75	25	4	16	20	43
53	3	54	43	59	24	4	17	03	43
52	3	55	39	56	23	4	17	46	43
51	3	56	34	55	22	4	18	30	44
50	3	57	28	54	21	4	19	15	45
49	3	58	18	50	20	4	19	59	44
48	3	59	08	50	19	4	20	43	44
47	3	59	55	47	18	4	21	25	42
46	4	00	42	47	17	4	22	08	43
45	4	01	28	46	16	4	22	51	43
44	4	02	11	43	15	4	23	34	43
43	4	02	56	45	14	4	24	18	44
42	4	03	43	47	13	4	25	03	45
41	4	04	32	49	12	4	25	48	45
40	4	05	21	49	11	4	26	32	44
39	4	06	10	49	10	4	27	15	43
38	4	06	56	46	9	4	27	59	44
37	4	07	41	45	8	4	28	42	43
36	4	08	24	43	7	4	29	25	43
35	4	09	08	44	6	4	30	09	44
34	4	09	52	44	5	4	30	51	42
33	4	10	37	45	4	4	31	32	41
32	4	11	20	43	3	4	32	16	44
31	4	12	03	43	2	4	33	07	51
30	4	12	47	44	1	4	34	15	68
29	4	13	30	43	Atlantic City	4	35	17	62 ½ mile
28	4	14	13	43	Time, 45 minutes 17 seconds.				

Complete detailed reports of the foregoing tests, with indicator diagrams, are on file in the office of the Baldwin Locomotive Works, and can be examined by any one interested.

LOCOMOTIVE DETAILS.

EACH locomotive has the builder's number plate attached to sides of smoke box directly over steam chests, except in small engines of special designs, when it is placed on smoke box door, or in some other conspicuous position. This plate contains the name of the manufacturers, the consecutive construction number of the engine, and the year in which constructed.

In ordering parts, in all cases where it is possible to do so, this construction number should be given, and when this cannot be obtained, the original road number, class number, or name should be supplied. This information will assist in referring to original records and facilitate the work of renewals.

The locomotive details and code words herein given can be used with reference to either broad or narrow-gauge locomotives.

INSTRUCTIONS FOR CABLING.

THE cable address is, "**Baldwin, Philadelphia.**"

All code words relating to duplicate parts begin with the letter "E."

Each of the tables accompanying the following plates has in large heavy letters opposite the plate number a code word, the use of which indicates that all the parts shown on the plate are required; and each of the items has opposite it a code word in small heavy letters indicating that only that particular piece is needed.

In all cases it is understood that a set or enough for one locomotive will be sent unless specific instructions to the contrary are given.

On pages 231-239 a list will be found of duplicate parts in groups, such as are generally ordered, with a code word corresponding to each group.

In answering inquiries for prices, the cost is made for delivery f. o. b. vessel in Philadelphia or New York, unless otherwise indicated.

The construction or consecutive number of the locomotive should be used in cabling and in writing orders. This is shown on the builder's plates, which are generally on the smoke box above the cylinders. Code words corresponding to construction numbers will be found in the tables herewith (pages 213–221), which range from 1 to 25000 (from 1 to 1000 inclusive proceeding by units, and from 1000 to 25000 proceeding by thousands).

Words consisting of more than ten letters are counted as two words. When the name of a railway or firm embraces two or more words containing ten letters or less in all, they can be cabled as one: for instance, "**Costarica** Railway" (two words), meaning Costa Rica Railway.

It is a rule of all telegraph companies that in cabling, three figures count as one word. Therefore, any construction number can be cabled in two words: for instance, 13 975 (13975), which would be counted two words. Inasmuch, however, as figures are more apt to be improperly transmitted than words, a table has been prepared (see page 213) by the use of which construction numbers can still be given in two words and some of them in one, these words being less liable to misconstruction than the figures.

Messages should be written very plainly, so that there can be no doubt as to the word used, and no possibility of the division of one word into two.

Upon application a code word will be assigned, representing the name of any railroad company or firm desiring to do business by cable with the Baldwin Locomotive Works.

Example: The construction number 6000 would be one word, "Eenlobbig;" while 6020 would be "Eenlobbig Earthworms," and 12540 "Eensgezind Ecofora" ("Eensgezind" standing for 12000 and "Ecofora" for 540). 6020 could also be 6 020, and 12540 be 12 540; but the word method is preferable.

Example: If it is desired to cable for a boiler complete, as shown on Plate 1, for engine 13978, to be shipped by steamer to Havana, Cuba, the message would read as follows (the signature should be the name of the company ordering or its code word):

HAVANA, January 10, 1895.

BALDWIN, Philadelphia.

Eerekrans
Ehrenruf
Eerewoord
Eensklaps
Eenbladig

(Signed) (Code name or actual name of Company.)

Translation:

HAVANA, January 10, 1895.

BALDWIN, Philadelphia.

Eerekrans . . Please ship by steamer as soon as possible duplicate parts covered by code word
Ehrenruf . . . Boiler and all parts on Plate 1.
Eerewoord . . For one locomotive, construction number
Eensklaps . } 13978.
Eenbladig . }

(Name of Company.)

But if a set of tubes were wanted, the message would read:

HAVANA, January 10, 1895.

BALDWIN, Philadelphia.

Eerekrans
Ehrgeizig
Eerewoord
Eensklaps
Eenbladig

(Signed) (Code name or actual name of Company.)

Translation:

HAVANA, January 10, 1895.

BALDWIN, Philadelphia.

Eerekrans . . Please ship by steamer as soon as possible duplicate parts covered by code word
Ehrgeizig . . Boiler tubes.
Eerewoord . . For one locomotive, construction number
Eensklaps . } 13978.
Eenbladig . }

(Name of Company.)

If three sets of tubes were wanted for the same locomotive, or for locomotives of the same dimensions, the message would read:

HAVANA, January 10, 1895.

BALDWIN, Philadelphia.

Eerekrans
Ehrgeizig
Eergierig
Eensklaps
Eenbladig

(Signed) (Code name or actual name of Company.)

Translation:

HAVANA, January 10, 1895.

BALDWIN, Philadelphia:

Eerekrans . . Please ship by steamer as soon as possible duplicate parts covered by code word

Ehrgeizig . . Boiler tubes.

Eergierig . . . For three locomotives, construction number

Eensklaps .
Eenbladig . } 13978.

(Name of Company.)

To order a pair of cylinders from Rio de Janeiro, Brazil, with parts attached, a message would read:

RIO, March 1, 1895.

BALDWIN, Philadelphia.

Eerekroon
Effricatum (see page 229.)
Eensdeels
Eddaic

(Signed) (Code name or actual name of Company.)

Translation:

RIO, March 1, 1895.

BALDWIN, Philadelphia.

Eerekroon . . Please ship by steamer as soon as possible duplicate parts covered by code word (see *) for locomotive, construction number (see **).

Effricatum . . * 1 pair cylinders with heads, covers, chests, caps, casings, glands, valves, yokes and pistons, painted and varnished.

Eensdeels .
Eddaic . . . } **11743.

(Name of Company.)

A cable message from Yokohama, Japan, for a crosshead for left side of locomotive 14126, would read as follows:

YOKOHAMA, March 22, 1895.

BALDWIN, Philadelphia.

Eeredienst
Eigilwich
Eeretomben
Eensnarig
Eboueuses

(Signed) (Code name or actual name of Company.)

Translation:

YOKOHAMA, March 22, 1895.

BALDWIN, Philadelphia.

Eeredienst . . Please ship by quickest freight route as soon as possible duplicate parts covered by code word
Eigilwich . . Crosshead.
Eeretomben . For left hand side of one locomotive, construction number
Eensnarig . } 14126.
Eboueuses . }

(Name of Company.)

RIO, March 1, 1895.

BALDWIN, Philadelphia.

Eerekrans
Eilamides
Eeresabels
Eenschalig
Ebaucheras
Eerstdaags

(Signed) (Code name or actual name of Company.)

Translation:

RIO, March 1, 1895.

BALDWIN, Philadelphia.

Eerekrans . . Please ship by steamer as soon as possible duplicate parts covered by code word

Eilamides . . Eccentric strap.

Eeresabels . . For right hand side of one locomotive, construction number

Eenschalig . } 10055.
Ebaucheras }

Eerstdaags . . Backward motion.

(Name of Company.)

CABLE CODE NUMBERS.

1 Eachwhere
2 Eactarius
3 Eadbert
4 Eadburge
5 Eadwin
6 Eager
7 Eagerly
8 Eagerness
9 Eagrass
10 Eanred
11 Eapse
12 Earinus
13 Earshrift
14 Earthiness
15 Earthling
16 Earthly
17 Earthquake
18 Earthward
19 Earthwork
20 Earthworms
21 Earwig
22 Earwort
23 Easeful
24 Easels
25 Easily
26 Easiness
27 Easium
28 Easterling
29 Easterly
30 Eastward
31 Eatable
32 Eatage
33 Eauzan
34 Eavagier
35 Ebahi
36 Ebalacon
37 Ebalette
38 Ebanacee
39 Ebanista
40 Ebanizar
41 Ebankers
42 Ebano
43 Ebanoyer
44 Ebaque
45 Ebarbement
46 Ebarbeuse
47 Ebarboir
48 Ebaroui
49 Ebattons
50 Ebattriez
51 Ebattront
52 Ebattu
53 Ebaubi
54 Ebauchage
55 Ebaucheras
56 Ebauchiez
57 Ebauchoir
58 Ebbeanker
59 Ebbeboom
60 Ebbene
61 Ebbenhout
62 Ebbero
63 Ebbestrom
64 Ebbezeit
65 Ebbing
66 Ebbrezza
67 Ebbrieta
68 Ebbrioso
69 Ebdomada
70 Ebelians
71 Ebenaceo
72 Ebenastre
73 Ebenbild
74 Ebeneous
75 Ebenezer
76 Ebenfalls
77 Ebenheit
78 Ebeni
79 Ebenier
80 Ebenistes
81 Ebenmass
82 Ebenoxyle
83 Ebenrecht
84 Ebensohle
85 Ebenspiel
86 Ebenuz
87 Ebenwage
88 Eberesche
89 Ebergement
90 Eberhard
91 Eberhirsch
92 Eberlue
93 Eberulf
94 Ebetazione
95 Ebetement
96 Ebeto
97 Ebeurrer
98 Ebeylieres
99 Ebiasaph
100 Ebionisme
101 Ebiscum
102 Ebiselc

103 Eblana
104 Eblandior
105 Eblanditus
106 Eblanine
107 Eblouimes
108 Eblouir
109 Eblouiras
110 Eblouired
111 Eblouiront
112 Eblouisses
113 Eboda
114 Ebonist
115 Ebonite
116 Ebonized
117 Eboraci
118 Eboracum
119 Eborarios
120 Eborense
121 Eborgnage
122 Eboribus
123 Ebosia
124 Ebouage
125 Eboueur
126 Eboueuses
127 Ebouffer
128 Ebouiger
129 Ebouilli
130 Eboulait
131 Eboulee
132 Eboulement
133 Ebouleront
134 Ebouleux
135 Ebouqueter
136 Ebouriffe
137 Ebouisine
138 Ebouter
139 Ebouture
140 Ebraiche
141 Ebraico
142 Ebraismo
143 Ebraisoir
144 Ebraizzano
145 Ebraizzare
146 Ebraizzava
147 Ebraizzo
148 Ebrancadas
149 Ebrancado
150 Ebranchait
151 Ebranchiez
152 Ebranchons
153 Ebranlait
154 Ebranler
155 Ebranliez
156 Ebranlions
157 Ebrasure
158 Ebreche
159 Ebreneur
160 Ebria
161 Ebriacus
162 Ebriation
163 Ebriativo
164 Ebriato
165 Ebriavisti
166 Ebriedad
167 Ebrietas
168 Ebriety
169 Ebrieux
170 Ebrillade
171 Ebriosa
172 Ebriosidad
173 Ebriositas
174 Ebriosos
175 Ebrious
176 Ebriulatus
177 Ebrodunum
178 Ebroin
179 Ebromagi
180 Ebromagus
181 Ebrondeur
182 Ebrosser
183 Ebrouait
184 Ebrouement
185 Ebruiter
186 Ebruiteras
187 Ebruitiez
188 Ebruitons
189 Ebrulpho
190 Ebucheter
191 Ebudae
192 Ebulinus
193 Ebulliate
194 Ebullicao
195 Ebulliency
196 Ebullition
197 Ebulo
198 Eburacum
199 Eburatus
200 Eburinorum
201 Eburiphore
202 Eburnation
203 Eburnean
204 Eburneos
205 Eburninae
206 Eburobriga
207 Eburodunum
208 Eburon
209 Eburones
210 Eburovices
211 Ebusus
212 Ecabochage
213 Ecabocher
214 Ecachement
215 Ecaffer
216 Ecafignon
217 Ecaflote
218 Ecagne
219 Ecaillage
220 Ecaillaire
221 Ecaille
222 Ecaillette
223 Ecalcarate
224 Ecaler
225 Ecalisseur

226 Ecalyptre
227 Ecangage
228 Ecanguer
229 Ecaqueur
230 Ecarasse
231 Ecarquille
232 Ecarrure
233 Ecart
234 Ecartais
235 Ecartasses
236 Ecartelait
237 Ecarteler
238 Ecartement
239 Ecarterais
240 Ecarteriez
241 Ecarteur
242 Ecartons
243 Ecatissage
244 Ecaude
245 Ecauvage
246 Ecbalion
247 Ecballium
248 Ecbasis
249 Ecbatic
250 Ecbibi
251 Ecbibitum
252 Ecbirsoma
253 Ecbolade
254 Ecbolique
255 Ecbyrsome
256 Eccanthis
257 Eccedemmo
258 Eccedendo
259 Eccedenza
260 Eccederai
261 Eccedero
262 Eccedessi
263 Eccedevamo
264 Eccedevate
265 Eccediate
266 Eccedo
267 Eccehomo
268 Ecceite
269 Eccentric
270 Eccentros
271 Eccessivo
272 Eccettuano
273 Eccettuare
274 Eccettuava
275 Eccheuma
276 Ecchymose
277 Ecchymosis
278 Eccillum
279 Eccitammo
280 Eccitando
281 Eccitarla
282 Eccitarono
283 Eccitassi
284 Eccitata
285 Eccitativo
286 Eccitatore
287 Eccitavamo
288 Eccitavate
289 Ecciterai
290 Eccitero
291 Eccitolla
292 Ecclesia
293 Ecclesians
294 Ecclesiola
295 Ecclinuse
296 Eccopeur
297 Eccrisis
298 Eccycleme
299 Ecderon
300 Ecdicus
301 Ecdippa
302 Ecdique
303 Ecdore
304 Ecdurorum
305 Ecdysies
306 Ecelenore
307 Ecepper
308 Ecerner
309 Ecerveler
310 Ecetera
311 Ecfisa
312 Ecfisesi
313 Ecfonesi
314 Ecfrassi
315 Ecgonine
316 Echacantos
317 Echacorvos
318 Echadico
319 Echadores
320 Echaduras
321 Echafaud
322 Echafauder
323 Echaillon
324 Echalas
325 Echalasser
326 Echamiento
327 Echampeau
328 Echampi
329 Echamplure
330 Echancrais
331 Echancrant
332 Echancrure
333 Echando
334 Echandole
335 Echanges
336 Echangiez
337 Echangions
338 Echangiste
339 Echapellas
340 Echapoter
341 Echappade
342 Echappiez
343 Echappons
344 Echarbon
345 Echarnoir
346 Echarpes
347 Echarseter
348 Echauboule

349 Echaudoir
350 Echauffer
351 Echauffure
352 Echaulant
353 Echaux
354 Echazones
355 Echeable
356 Echeancier
357 Echebulus
358 Echeclea
359 Echecrates
360 Echecs
361 Echedamia
362 Echeggia
363 Echeggiano
364 Echeggiare
365 Echeggiava
366 Echelades
367 Echelaos
368 Echelidae
369 Echelonner
370 Echeneide
371 Echeneidis
372 Echeniller
373 Echephron
374 Echepolis
375 Echeveria
376 Echevinage
377 Echidna
378 Echidnine
379 Echidorus
380 Echignole
381 Echimyd
382 Echimyside
383 Echinacee
384 Echinaria
385 Echinated
386 Echinidae
387 Echinidans
388 Echinipede
389 Echinital
390 Echinite
391 Echinocere
392 Echinoderm
393 Echinodore
394 Echinogale
395 Echinogyne
396 Echinoide
397 Echinome
398 Echinomys
399 Echinopo
400 Echinopode
401 Echinorhin
402 Echinozoa
403 Echinulate
404 Echinus
405 Echinussa
406 Echionides
407 Echiopsis
408 Echiquete
409 Echite
410 Echiuride
411 Echkendji
412 Echmagoras
413 Echnomos
414 Echoes
415 Echoicus
416 Echoing
417 Echome
418 Echometer
419 Echometria
420 Echometro
421 Echonele
422 Echopolus
423 Echoppage
424 Echoppe
425 Echoton
426 Echouage
427 Echouais
428 Echouasses
429 Echouer
430 Echouerais
431 Echoueriez
432 Echoueront
433 Echouiez
434 Echouons
435 Echrefite
436 Echsenbrut
437 Echsenei
438 Echtbreken
439 Echtbreuk
440 Echteband
441 Echtebed
442 Echtelijk
443 Echtgareel
444 Echtgenoot
445 Echtheit
446 Echthre
447 Echting
448 Echtkoets
449 Echtwort
450 Echura
451 Ecidine
452 Ecimable
453 Eckard
454 Eckband
455 Eckbert
456 Eckehard
457 Eckelhaft
458 Eckeln
459 Eckenhalm
460 Eckenzahl
461 Eckerganz
462 Eckermast
463 Eckhaus
464 Eckkegel
465 Ecklade
466 Ecklonie
467 Eckplatz
468 Ecksaal
469 Ecksaeulen
470 Eckschuh
471 Eckstamm

472 Eckstein
473 Eckthor
474 Ecktisch
475 Eckzahn
476 Eclactisme
477 Eclaffer
478 Eclair
479 Eclairage
480 Eclairais
481 Eclairci
482 Eclaircise
483 Eclairons
484 Eclampsy
485 Eclanche
486 Eclandre
487 Eclapsia
488 Eclapside
489 Eclatable
490 Eclatais
491 Eclateriez
492 Eclatons
493 Ecleche
494 Eclecticos
495 Eclectique
496 Eclectiser
497 Eclectisme
498 Eclectizar
499 Eclegma
500 Eclepsis
501 Eclesiarca
502 Eclettismo
503 Eclidon
504 Ecligmata
505 Ecligmatis
506 Ecligmatum
507 Eclingure
508 Eclipsable
509 Eclipsais
510 Eclipsar
511 Eclipsaron
512 Eclipse
513 Eclipsons
514 Eclipticus
515 Eclissage
516 Eclissammo
517 Eclissando
518 Eclissassi
519 Eclissava
520 Eclisser
521 Eclisso
522 Eclittica
523 Eclogarius
524 Eclogarum
525 Eclopper
526 Eclore
527 Ecloses
528 Eclosion
529 Eclusa
530 Eclusement
531 Ecmatyrie
532 Ecmelia
533 Ecnephias
534 Ecnomus
535 Ecobuer
536 Ecochelage
537 Ecocheler
538 Ecoeurant
539 Ecoeurer
540 Ecofora
541 Ecofrai
542 Ecoica
543 Ecoicos
544 Ecoincon
545 Ecolage
546 Ecole
547 Ecolerer
548 Ecoliers
549 Ecometria
550 Ecometro
551 Econduirai
552 Economat
553 Economicas
554 Economico
555 Economique
556 Economist
557 Economizar
558 Economize
559 Econtrario
560 Econverso
561 Ecoper
562 Ecoperche
563 Ecoquer
564 Ecorcage
565 Ecorchant
566 Ecorchasse
567 Ecorcheler
568 Ecorchiez
569 Ecorcons
570 Ecornifle
571 Ecossain
572 Ecossaises
573 Ecossoneux
574 Ecotado
575 Ecotant
576 Ecotard
577 Ecouailles
578 Ecouanette
579 Ecouchures
580 Ecoulard
581 Ecoulera
582 Ecoulerait
583 Ecourgee
584 Ecourgeon
585 Ecourtant
586 Ecoussage
587 Ecoutames
588 Ecoutasses
589 Ecouterais
590 Ecouterons
591 Ecouteur
592 Ecoutille
593 Ecoutillon
594 Ecoutoir

595 **Ecouvette**
596 **Ecphasis**
597 **Ecphlysis**
598 **Ecphoneme**
599 **Ecphonesis**
600 **Ecphora**
601 **Ecphorarum**
602 **Ecphoris**
603 **Ecphorome**
604 **Ecphractic**
605 **Ecphraste**
606 **Ecphyma**
607 **Ecphymote**
608 **Ecphyse**
609 **Ecphysese**
610 **Ecpiema**
611 **Ecpiesme**
612 **Ecpleope**
613 **Ecplerome**
614 **Ecplessia**
615 **Ecplexie**
616 **Ecpnoe**
617 **Ecpyeme**
618 **Ecpyesis**
619 **Ecpyetique**
620 **Ecpyrosis**
621 **Ecqui**
622 **Ecquod**
623 **Ecrabouir**
624 **Ecrache**
625 **Ecraigne**
626 **Ecrainier**
627 **Ecrapette**
628 **Ecrasable**
629 **Ecrasais**
630 **Ecraser**
631 **Ecraserais**
632 **Ecraseriez**
633 **Ecrasiez**
634 **Ecrasure**
635 **Ecremaison**
636 **Ecremer**
637 **Ecremillon**
638 **Ecremoire**
639 **Ecrevisse**
640 **Ecrhexis**
641 **Ecriames**
642 **Ecrieront**
643 **Ecrille**
644 **Ecrirons**
645 **Ecrise**
646 **Ecriteau**
647 **Ecritmo**
648 **Ecritoire**
649 **Ecriturer**
650 **Ecrivaille**
651 **Ecrivimes**
652 **Ecroe**
653 **Ecroistre**
654 **Ecrouellet**
655 **Ecrouir**
656 **Ecroutage**
657 **Ecrysie**
658 **Ecsarcome**
659 **Ecstacy**
660 **Ecstasize**
661 **Ecstatic**
662 **Ecstatical**
663 **Ectadion**
664 **Ectatique**
665 **Ectatops**
666 **Ectenes**
667 **Ecthese**
668 **Ecthesien**
669 **Ecthlimme**
670 **Ecthlipse**
671 **Ecthlipsis**
672 **Ecthyma**
673 **Ecthymose**
674 **Ecthymosis**
675 **Ectilotici**
676 **Ectimosi**
677 **Ectipo**
678 **Ectobie**
679 **Ectoblast**
680 **Ectocarpe**
681 **Ectocyste**
682 **Ectoderme**
683 **Ectogramma**
684 **Ectolitro**
685 **Ectometro**
686 **Ectonstero**
687 **Ectopage**
688 **Ectopagia**
689 **Ectophyte**
690 **Ectopia**
691 **Ectopogono**
692 **Ectopones**
693 **Ectosarc**
694 **Ectosmie**
695 **Ectozoa**
696 **Ectrogenie**
697 **Ectromata**
698 **Ectromatis**
699 **Ectrome**
700 **Ectroparum**
701 **Ectropical**
702 **Ectropio**
703 **Ectrotico**
704 **Ectrotique**
705 **Ectylotic**
706 **Ectypal**
707 **Ectype**
708 **Ectypique**
709 **Ectyporum**
710 **Ecuable**
711 **Ecuacion**
712 **Ecuanteur**
713 **Ecubier**
714 **Ecueil**
715 **Ecuiage**
716 **Ecuieo**
717 **Ecumais**

718	Ecumant	759	Edelfink	800	Edentamus
719	Ecumenical	760	Edelfisch	801	Edentation
720	Ecumenico	761	Edelfrau	802	Edento
721	Ecumeresse	762	Edelfuchs	803	Edentula
722	Ecumeront	763	Edelgarbe	804	Edentulus
723	Ecumeux	764	Edelhengst	805	Edeopalmo
724	Ecumions	765	Edelhof	806	Edepoe
725	Ecumoire	766	Edelknabe	807	Edera
726	Ecunemica	767	Edelknecht	808	Ederaceo
727	Ecunemicos	768	Edelkrebs	809	Ederaceus
728	Ecuorea	769	Edellehen	810	Ederato
729	Ecuoreos	770	Edelmann	811	Ederoso
730	Ecureuil	771	Edelmarder	812	Edesio
731	Ecusson	772	Edelmass	813	Edesseno
732	Ecussonne	773	Edelmoedig	814	Edessenus
733	Ecvolorum	774	Edelmogend	815	Edesside
734	Ecvolus	775	Edelmuth	816	Edetana
735	Eczematous	776	Edelopal	817	Edetanos
736	Edacidade	777	Edelraut	818	Edgar
737	Edacious	778	Edelreis	819	Edgeless
738	Edaciously	779	Edelrose	820	Edgewise
739	Edacissimo	780	Edelschoen	821	Edgythe
740	Edacitatis	781	Edelsinn	822	Edharz
741	Edacite	782	Edelsinnig	823	Edhemite
742	Edaphodont	783	Edelstahl	824	Edibility
743	Eddaic	784	Edelstolz	825	Edible
744	Eddas	785	Edelthat	826	Edibleness
745	Eddered	786	Edelthier	827	Edicaria
746	Eddering	787	Edelvrouw	828	Edicendum
747	Eddoes	788	Edelweiss	829	Edichio
748	Edealogia	789	Edematico	830	Edicola
749	Edeatros	790	Edematoso	831	Edictabam
750	Edecan	791	Edematous	832	Edictabis
751	Edecanes	792	Edemera	833	Edictalium
752	Edecimamus	793	Edenique	834	Edictamus
753	Edecimatum	794	Edenisch	835	Edictarem
754	Edecimavi	795	Edenize	836	Edictavi
755	Edelaardig	796	Edenizing	837	Edictione
756	Edeldame	797	Edenruine	838	Edictionis
757	Edelerde	798	Edental	839	Edictorum
758	Edelfest	799	Edentalous	840	Edicule

841 Ediderunt
842 Edidici
843 Edidicimus
844 Edidisti
845 Edifiant
846 Edificaban
847 Edificacao
848 Edificada
849 Edificados
850 Edificao
851 Edifice
852 Edificios
853 Edifiement
854 Edifieras
855 Edifieriez
856 Edifieront
857 Edifiques
858 Edifizio
859 Edify
860 Edifying
861 Edifyingly
862 Edikt
863 Edilberto
864 Edileship
865 Edilicio
866 Edilidade
867 Edilita
868 Edilitaire
869 Ediografia
870 Ediologia
871 Ediosmo
872 Ediotide
873 Ediotomia
874 Edisaro
875 Edisma
876 Edisseris
877 Edisserto
878 Editeur
879 Editicia
880 Editioned
881 Editioning
882 Editor
883 Editores
884 Editorial
885 Editoribus
886 Editorship
887 Editress
888 Editresses
889 Edituate
890 Edituating
891 Edixerimus
892 Edixi
893 Ediximus
894 Edixissem
895 Edizione
896 Edmondie
897 Edmundo
898 Edoardo
899 Edocenter
900 Edocephale
901 Edoctum
902 Edocuerunt
903 Edocui
904 Edocuisti
905 Edolandi
906 Edolandos
907 Edolandum
908 Edolatorum
909 Edolatum
910 Edolavisti
911 Edolien
912 Edomitas
913 Edomitavi
914 Edomiter
915 Edoner
916 Edonio
917 Edonismo
918 Edonorum
919 Edormisco
920 Edossage
921 Edostome
922 Edredon
923 Edredones
924 Edris
925 Edrisiden
926 Edrum
927 Educacao
928 Educadores
929 Educados
930 Educaremus
931 Educate
932 Educateur
933 Educative
934 Educatore
935 Educatrix
936 Educatum
937 Educaturi
938 Educaturos
939 Educaturum
940 Educavano
941 Educavisti
942 Educavit
943 Educeret
944 Educeretis
945 Educhiamo
946 Eductor
947 Edulcare
948 Edulcorado
949 Edulcorant
950 Edulcoreis
951 Edulica
952 Edulious
953 Edulis
954 Edumia
955 Eduquant
956 Eduquemos
957 Eduques
958 Edurescis
959 Edurorum
960 Edwardsie
961 Edwarsite
962 Edwig
963 Edyllium

964	Edzard
965	Eedbrekers
966	Eedbreuk
967	Eedgespan
968	Eegaas
969	Eekhakker
970	Eekhandel
971	Eekhoren
972	Eelbuck
973	Eelpot
974	Eelspear
975	Eeltachtig
976	Eelterig
977	Eeltzweer
978	Eenbladig
979	Eenbloemig
980	Eendebout
981	Eendenei
982	Eendenhok
983	Eendenkom
984	Eendenkooi
985	Eendennest
986	Eendenroer
987	Eender
988	Eendeveder
989	Eendjes
990	Eendracht
991	Eendvogels
992	Eengrepig
993	Eenhandig
994	Eenheid
995	Eenhelmig
996	Eenhoekig
997	Eenhoofdig
998	Eenhoorn
999	Eenhoornig
1,000	Eenhuizig
2,000	Eenigerlei
3,000	Eeniglijk
4,000	Eenkennig
5,000	Eenkleurig
6,000	Eenlobbig
7,000	Eenoog
8,000	Eenoogig
9,000	Eenrijm
10,000	Eenschalig
11,000	Eensdeels
12,000	Eensgezind
13,000	Eensklaps
14,000	Eensnarig
15,000	Eenspan
16,000	Eenstemmig
17,000	Eenstijlig
18,000	Eenvakkig
19,000	Eenvervig
20,000	Eenvinnig
21,000	Eenvoetig
22,000	Eenvoud
23,000	Eenvoudig
24,000	Eenwijvig
25,000	Eenzaam

USEFUL SENTENCES FOR CABLING FOR PARTS OF LOCOMOTIVES.

Eenzelvig . . At what price and how soon can you ship duplicate parts covered by code word .... ?

Eenzijdig . . How soon can you ship duplicate parts covered by code word .... ?

Eeotomous . . Please ship by express as soon as possible duplicate parts covered by code word ....

Eerambt . . . Please ship by express as soon as possible duplicate parts covered by code word .... for locomotive, construction number ....

Eerbetoon . . Please ship by freight as soon as possible duplicate parts covered by code word ....

Eereblijk . . . Please ship by freight as soon as possible duplicate parts covered by code word .... for locomotive, construction number ....

Eereboog . . . Please ship overland as soon as possible duplicate parts covered by code word ....

Eeredegen . . Please ship overland as soon as possible duplicate parts covered by code word .... for locomotive, construction number ....

Eeredienst . . Please ship by quickest freight route as soon as possible duplicate parts covered by code word ....

Eeregraf . . . Please ship by quickest freight route as soon as possible duplicate parts covered by code word .... for locomotive, construction number ....

Eerekrans . . Please ship by steamer as soon as possible duplicate parts covered by code word ....

Eerekroon . . Please ship by steamer as soon as possible duplicate parts covered by code word .... for locomotive, construction number ....

Eeremantel . . Please ship by sailing vessel as soon as possible duplicate parts covered by code word ....

Eereplaats . . Please ship by sailing vessel as soon as possible duplicate parts covered by code word.................. for locomotive, construction number....................

Eerepoort . . Please ship by steamer as soon as possible duplicate parts to the value of $....................

Eerepost . . . Please ship by steamer as soon as possible duplicate parts to the value of $..................for locomotive, construction number....................

Eereposten . Please ship by sailing vessel as soon as possible duplicate parts to the value of $....................

Eereprijs . . . Please ship by sailing vessel as soon as possible duplicate parts to the value of $.................... for locomotive, construction number....................

Eeresabels . . For right hand side of one locomotive, construction number....................

Eereschot . . For right hand side of two locomotives, construction number....................

Eerestoel . . . For right hand side of three locomotives, construction number....................

Eeretempel . For right hand side of four locomotives, construction number....................

Eeretitels . . For right hand side of five locomotives, construction number....................

Eeretomben . For left hand side of one locomotive, construction number....................

Eeretrap . . . For left hand side of two locomotives, construction number....................

Eerewacht . . For left hand side of three locomotives, construction number....................

Eerewapen . . For left hand side of four locomotives, construction number....................

Eerewijn . . . For left hand side of five locomotives, construction number....................

Eerewoord . . For one locomotive, construction number....................

Eergevoel . . For two locomotives, construction number....................

Eergierig . . . For three locomotives, construction number....................

Eerlijk . . . . For four locomotives, construction number....................

Eerlijker . . . For five locomotives, construction number....................

Eerloozer . . For six locomotives, construction number....................

Eermetaal . . For seven locomotives, construction number....................

Eernamen . . For eight locomotives, construction number....................

Eerpenning	For nine locomotives, construction number ....
Eerroof	For ten locomotives, construction number ....
Eerroovend	Hold order of .... until you receive further instructions.
Eershalve	Forward motion.
Eerstdaags	Backward motion.
Eertijds	
Eervol	
Eervoller	
Eerwaarde	
Eerwaardig	
Eerzamer	
Eerzucht	
Eerzuchtig	
Eesting	
Eestmout	
Eetbak	
Eethuis	
Eethuizen	
Eetion	
Eetionem	
Eetkamers	
Eetlepels	
Eetlust	
Eetmalen	
Eetplaats	
Eetregel	
Eetsters	
Eettafel	
Eetwaar	
Eetzaal	
Eeuwen	
Eeuwenoud	
Eeuwfeest	
Eeuwjaar	
Eeuwspel	
Eeuwzang	
Eeuwzangen	
Efantel	
Efaufile	
Efectuado	

Efectuamos . .
Efectuaron . .
Efectuases . .
Efectueis . . .
Efedra . . . .
Efemerides . .
Efemerie . . .
Efesias . . .
Efesio . . . .
Efestite . .
Efetico . . . .
Effable . . . .
Effacable . . .
Effacage . . .
Effacais . . .
Effacasses . .
Effacerais . .
Effaceriez . .
Effacerons . .
Effacest . . .
Effacing . . .
Effacons . . .
Effaecata . . .
Effaecatus . .
Effaner . . . .
Effanures . .
Effarcimus . .
Effarcio . . .
Effarciunt . .
Effarement . .
Effarvatte . .
Effatio . . . .
Effatione . . .
Effatorum . .
Effauce . . .
Effaumer . . .
Effeccao . . .
Effecerim . . .
Effecissem . .
Effectible . . .
Effectif . . . .

Effectione . .
Effectivo . . .
Effectivus . . .
Effectless . . .
Effectrix . . .
Effectuais . .
Effectuar . . .
Effectuose . .
Effecundo . .
Effeiance . . .
Effeito . . . .
Effeituoso . .
Effelure . . .
Effeminar . .
Effeminava . .
Effeminize . .
Effendi . . . .
Effenende . .
Effenheid . . .
Effening . . .
Efferascis . . .
Efferasco . . .
Efferatio . . .
Efferatus . . .
Efferous . . .
Effersimus . .
Effersisti . . .
Effervens . . .
Efferveo . . .
Effervesce . .
Effestria . . .
Effestuer . . .
Effete . . . .
Effettore . . .
Effettrice . . .
Effettuato . .
Effettuavi . .
Effeuiller . . .
Effezione . . .
Efficacia . . .
Efficaz . . .

Efficiency . . .
Efficient . . .
Efficienza . . .
Efficta . . . .
Effictorum . .
Effictum . .
Effierced . . .
Effiercing . . .
Effigiado . . .
Effigiar . . .
Effigiassi . .
Effigiava . . .
Effigie . . . .
Effigierai . . .
Effiloche . . .
Effiloquer . . .
Effimero . . .
Effindere . . .
Efflagitas . . .
Efflagito . . .
Efflammans . .
Efflanque . . .
Efflation . . .
Efflatos . . . .
Effleurais . . .
Effleure . . . .
Efflevisti . . .
Efflictim . . .
Effloreo . . .
Effloremus . .
Effloresce . . .
Efflorui . . . .
Efflower . . .
Effluencia . .
Effluente . . .
Effluescis . . .
Effluvial , . .
Effluvio . . .
Effluvioso . . .
Effluxed . . .
Effluxing . . .

Effluxorum . .
Effocare . . .
Effoderunt . .
Effodimus . .
Effodisti . . .
Effoedis . . .
Effoedo . . .
Effondrait . .
Effondront . .
Effor . . . .
Efforcais . . .
Efforcant . . .
Efforcing . . .
Efforcions . .
Efforeria . . .
Efformed . . .
Efformier . . .
Effortless . . .
Effossioni . . .
Effossum . . .

GROUPS OF DUPLICATE PARTS WITH CODE WORDS.

[In some cases it will be more convenient to order parts by using these group words; in others by a reference to the plates. See index (page 429) to find part needed.]

Effouage . . . 1 Boiler with Tubes, Double Cone, Dry Pipe, Throttle work complete, including Stuffing Box and Gland, Dome Cap and Safety Valves, Smoke Box, Front and Door, Fire Door with Liner and Frame and Cleaning Plugs, tested and primed.

Effoueil . . . 1 Boiler with Tubes and Cleaning Plugs only, tested and primed.

Effractor . . . 1 Fire Box.

Effracture . . 1 Set Boiler Tubes.

Effrange . . . 1 Set Boiler Tube Ferrules.

Effrayable . . 1 Double Cone.

Effrayer . . . 1 Set Steam Pipes.

Effrayeras . . 1 Throttle Valve, Box, Pipe, Elbow, Crank, and Rod.

Effrayiez . . . 1 Smoke Box Front and Door.

Effrayons . . 1 Fire Door with Frame and Liner.

Effreement . . 1 Set Cleaning Plugs.

Effrenatio . . 1 Set Fusible Plugs.

Effrenatus . . 1 Set Boiler Lagging.

Effrenibus . . 1 Set Boiler Jacket.

Effrenis . . . 1 Set Boiler Jacket Bands.

Effricare . . . 1 Set Safety Valves, complete.

Effricatum . . 1 Pair Cylinders with Heads, Covers, Chests, Caps, Casings, Glands, Valves, Yokes and Pistons, painted and varnished.

Effrico . . . . 1 Pair Finished Cylinders, bolted together, without any fittings.

Effrique . . . 1 Set Front Cylinder Heads.

Effriter . . . . 1 Set Back Cylinder Heads.

Effrixisti . . . 1 Set Front Cylinder Covers.

Effroisser . . 1 Set Back Cylinder Covers.

Effruitant . . 1 Set Cylinder Glands and Bottom Rings.

Effrutico . . . 1 Set Metallic Packing complete, for Piston Rods and Valve Stems.
Effugio . . . . 1 Set Composition Rings for Metallic Packing of Piston Rods and Valve Stems.
Effugisti . . . 1 Set Cylinder Casings.
Effugitos . . . 1 Set Steam Chests.
Effugiunt. . . 1 Set Steam Chest Caps or Lids.
Effulcrate . . 1 Set Steam Chest Glands and Bottom Rings.
Effulge . . . . 1 Set Steam Chest Casings.
Effulgence . . 1 Set Steam Chest Casing Covers.
Effulgent . . . 1 Set Steam Chest Valves.
Effulgetis . . 1 Set Steam Chest Valve Yokes.
Effulsio . . . 1 Set Steam Chest Relief Valves.
Effulsioni . . 1 Set Pistons with Rods and Packing.
Effultorum . . 1 Set Piston Rods.
Effultus . . . 1 Set Piston Packing.
Effumable . . 1 Pair Cylinders with Heads, Covers, Casings, Valves, Stems, Pistons, Metallic Piston Rod and Valve Stem Packing, complete (Vauclain Compound System).
Effumant. . . 1 Pair Finished Cylinders with Bushings, bolted together, but without other fittings (Vauclain Compound System).
Effumigare . . 1 Set Front Cylinder Heads, High Pressure (Vauclain Compound System).
Effuming . . . 1 Set Back Cylinder Heads, High Pressure (Vauclain Compound System).
Effundica . . 1 Set Front Cylinder Head Casing Covers, High Pressure (Vauclain Compound System).
Effundir . . . 1 Set Back Cylinder Head Casing Covers, High Pressure (Vauclain Compound System).
Effundo . . . 1 Set Front Cylinder Heads, Low Pressure (Vauclain Compound System).
Effusion . . . 1 Set Back Cylinder Heads, Low Pressure (Vauclain Compound System).
Effusive . . . 1 Set Front Cylinder Head Casing Covers, Low Pressure (Vauclain Compound System).
Effusively . . 1 Set Back Cylinder Head Casing Covers, Low Pressure (Vauclain Compound System).
Effusoris . . . 1 Set Front Valve Chamber Heads (Vauclain Compound System).

Effusorum . . 1 Set Back Valve Chamber heads (Vauclain Compound System).
Effuticius . . 1 Set Front Valve Chamber Head Casing Covers (Vauclain Compound System).
Effutile . . . . 1 Set Back Valve Chamber Head Casing Covers (Vauclain Compound System).
Effutilis . . . 1 Set Valve Chamber Bushings (Vauclain Compound System).
Effutilium . . 1 Set Main Piston Valves with Rings (Vauclain Compound System).
Efialte . . . . 1 Set Main Piston Valves with Rings and Stems (Vauclain Compound System).
Eficiencia . . 1 Set Main Piston Valve Rings (Vauclain Compound System).
Efigies . . . . 1 Set Pistons with Rods and Packing, High Pressure (Vauclain Compound System).
Eflagelle . . . 1 Set Pistons with Rods and Packing, Low Pressure (Vauclain Compound System).
Efourceau . . 1 Set Piston Packing Rings, High Pressure (Vauclain Compound System).
Efraimo . . . 1 Set Piston Packing Rings, Low Pressure (Vauclain Compound System).
Efusal . . . . 1 Set Piston Rods (Vauclain Compound System).
Egagre . . . . 2 Starting Valves (Vauclain Compound System).
Egagropilo . . 4 Cylinder Cocks (Vauclain Compound System).
Egailler . . . 1 Set Cylinder Relief Valves (Vauclain Compound System).
Egalement . . 1 Set Frames without Fittings.
Egalisage . . 1 Set Frame Front Rails.
Egaliser . . . 1 Set Frame Pedestal Caps.
Egaliseras . . 1 Set Pedestal Wedges.
Egalisons . . 1 Set Pedestal Wedge Bolts.
Egalitaire . . 1 Set Pedestal Gibs.
Egalite . . . . 1 Set Driving Wheels Complete, on Axles with Eccentrics, Eccentric Straps, and Boxes, painted and varnished.
Egancette . . 1 Set Driving Tires.
Egarerais . . 1 Set Wrist Pins.
Egareriez . . 1 Set Driving Axles.
Egareront . . 1 Set Eccentrics.
Egariez . . . 1 Set Eccentric Straps.

Egarons . . . 1 Set Guides with Filling Pieces.
Egarrotte . . . 1 Set Crossheads.
Egauler . . . 1 Set Crosshead Gibs.
Egayantes . . 1 Set Crosshead Filling Pieces.
Egayasses . . 1 Set Crosshead Pins.
Egayer . . . . 1 Set Rods complete, except Oil Cups.
Egayeras . . . 1 Set Rod Brasses.
Egayions . . . 1 Set Rod Straps.
Egberto . . . 1 Set Rod Keys.
Egdauama . . 1 Set Rod Straps with Brasses, Keys, Bolts and Set Screws.
Egeenne . . . 1 Set Links complete, with Blocks, Lifters, Eccentric Rods and all Pins.
Egeirino . . . 1 Reverse Shaft.
Egelamus . . 1 Set Reverse Shaft Bearings.
Egelantier . . 1 Set Rockshafts.
Egelbeere . . 1 Set Rocker Boxes.
Egelgras . . . 1 Set Valve Rods.
Egelidamus . 1 Counterbalance Spring.
Egelidas . . . 1 Pump Complete.
Egelkruid . . 1 Pump Plunger.
Egelochus . . 1 Pump Feed Cock.
Egentium . . 1 Pump Check complete.
Egenulorum . 1 Complete Set of Springs.
Egerane . . . 1 Set Driving Springs.
Egermage . . 1 Set Driving Spring Links.
Egersimon . . 1 Set Engine Truck Springs.
Egesaretus . . 1 Set Tender Springs.
Egesippe . . . 1 Forward Equalizing Beam.
Egestas . . . 1 Forward Equalizing Beam Fulcrum.
Egestione . . 1 Set Equalizing Beams.
Egestionis . . 1 Set Equalizing Beam Fulcrums.
Egestorum . . 1 Bell with Clapper and Tongue.
Egestosi . . . 1 Bell with Clapper and Tongue, Frame, Yoke and Crank.
Egestosus . . 1 Sand Box complete.
Egestuum . . 1 Smoke Stack complete with Base.
Eggaree . . . 1 Smoke Stack Base complete.
Eggebalken . . 1 Smoke Stack Cone.
Eggehaken . . 1 Smoke Stack Netting.
Eggement . . 1 Set Grate Bars.

Eggen	1 Set Grate Frames or Holders.
Eggerigst . . .	1 Set Rocking Grates, with all Fixtures.
Eggerling. . .	1 Set Engine Truck Boxes with Brasses and Cellars.
Eggiger. . . .	1 Set Engine Truck Box Brasses.
Eggigheid. . .	1 Set Engine Truck Box Cellars.
Eghiazar . . .	1 Set Driving Boxes with Brasses and Cellars.
Egialus . . .	1 Set Driving Box Brasses.
Egidarmato. .	1 Set Driving Box Cellars.
Egidio	1 Set Tender Boxes with Lids, Wedges and Brasses.
Egifila	1 Set Tender Boxes with Lids.
Egignere . . .	1 Set Tender Box Wedges.
Egilopical . .	1 Set Tender Box Brasses.
Eginetique . .	1 Engine Truck complete, with Wheels, Boxes, etc., painted and varnished.
Eginopside . .	1 Engine Truck complete, except Wheels and Boxes.
Egiochus . . .	1 Engine Truck Centre Pin.
Egipciana . .	1 Engine Truck Swing Bolster.
Egipcios . . .	1 Engine Truck Frame.
Egipiro	2 Engine Truck Wheels without Axles, bored.
Egiptologo . .	1 Pair Engine Truck Wheels on Axles, painted and varnished.
Egirine	1 Pilot.
Egissent . . .	1 Pilot Bull Nose.
Egiziache. . .	1 Pilot Draw Bar.
Egiziaco . . .	1 Engine Front Draw Casting.
Eglecopala . .	1 Water Gauge complete.
Egloga	12 Water Gauge Glasses.
Eglogiste . . .	1 Water Gauge Lamp.
Egloguista . .	1 Injector.
Eglon	1 Injector Steam Valve.
Egmond . . .	1 Injector Feed Cock.
Egnatia . . .	1 Injector Check.
Egnatius . . .	1 Steam Gauge.
Egoarico . . .	1 Steam Gauge Stand.
Egoasinha . .	1 Steam Gauge Lamp.
Egobole . . .	12 Steam Gauge Lamp Globes.
Egobuer . . .	1 Steam Gauge Lamp Stand.
Egofonia . . .	1 Blower Valve.
Egoger . . .	1 Heater Valve.
Egohine . . .	1 Steam Brake Valve for Engineer.
Egoical . . .	1 Steam Brake Stop Valve.

Egoismar . . .	1 Blow-off Cock.
Egoismo . . .	1 Set Gauge Cocks.
Egoistical . .	1 Set Cylinder Cocks.
Egoistique . .	1 Sight Feed Cylinder Lubricator.
Egoity	1 Set Cab Cylinder Oilers, B. L. W. style.
Egoletro . . .	1 Set Condensing Steam Chest Oil Cups.
Egologie . . .	1 Set Rod Oil Cups.
Egologique . .	1 Set Guide Oil Cups.
Egomet . . .	1 Set Rock Shaft Oil Cups.
Egomiste . . .	1 Set Eccentric Strap Oil Cups.
Egophone . .	1 Whistle.
Egopodio . . .	1 Headlight.
Egopogono . .	1 Throttle Lever complete, with Quadrant, Latch, Link, Stud, Handle and Spring.
Egoprico . . .	1 Reverse Lever complete.
Egoprosope .	1 Reverse Lever Rod, or Reach Rod.
Egorgement .	1 Set Cab Brackets.
Egorgeoir . .	1 Set Cab Bracket Plates.
Egorgeront . .	1 Foot Plate.
Egorgille . . .	1 Tender Wedge.
Egosiller . . .	1 Tender Wedge Box.
Egotheism . .	1 Engine Back Draw Bar.
Egothele . . .	1 Exhaust Nozzle and Thimbles.
Egotism . . .	1 Set Exhaust Nozzle Thimbles.
Egotistic . . .	1 Set Smoke Box Netting.
Egotize . . .	1 Spark Ejector.
Egotizing . .	1 Spark Ejector Valve.
Egout	1 Set Smoke Box Cleaning Holes and Caps
Egoutier . . .	1 Set Driving Brake Shoes.
Egouttage . .	1 Set Driving Brake Heads.
Egraffigne . .	1 Set Brake Cylinders complete, with Pistons and Rods.
Egrageure . .	1 Set Driving Brake Cams.
Egrainage . .	1 Tank with Funnel and Lid, Valves, Lugs and Handles, painted and varnished.
Egrainoir . . .	1 Tank Funnel and Lid.
Egramente . .	1 Tank Cock.
Egraminer . .	1 Tender, complete on Wheels, painted and varnished.
Egrappage . .	1 Tender Chafing Casting.
Egrapper . . .	1 Tender Front Draw Casting.

Egratigner . . . 1 Tender Back Draw Casting.
Egravoir . . . . 1 Set Tender Frame Centre Pins.
Egregiat. . . . 1 Set Tender Pedestals.
Egregiorum . 1 Set Tender Trucks complete, with Wheels painted and varnished.
Egregious . . 1 Tender truck complete, with Wheels painted and varnished.
Egregores . . 1 Set Tender Trucks complete, without Wheels and Boxes.
Egrenement . 1 Tender Truck complete, without Wheels and Boxes.
Egressao. . . 1 Set Tender Truck Centre Plates.
Egressed . . 1 Set Tender Wheels on Axles, painted and varnished.
Egressing . . 1 Pair Tender Wheels on Axle, painted and varnished.
Egribos . . . 1 Set Tender Wheels without Axles.
Egrillard . . . 1 Set Tender Brake Shoes.
Egriot . . . . 1 Set Tender Brake Heads.
Egrisage . . . 1 Cab.
Egritude . . .
Egrotant . . .
Egsmeden . .
Egsmederij .
Egsmid . . .
Egtand . . . .
Egtanden . . .
Egualendo . .
Egualezza . .
Egualimmo . .
Egualirai . . .
Egualisco . . .
Egualissi . . .
Egualito . . .
Egueille . . .
Eguerunt . .
Eguilles . . .
Eguimus . . .
Eguisier . . .
Eguisti . . .
Egularum . .

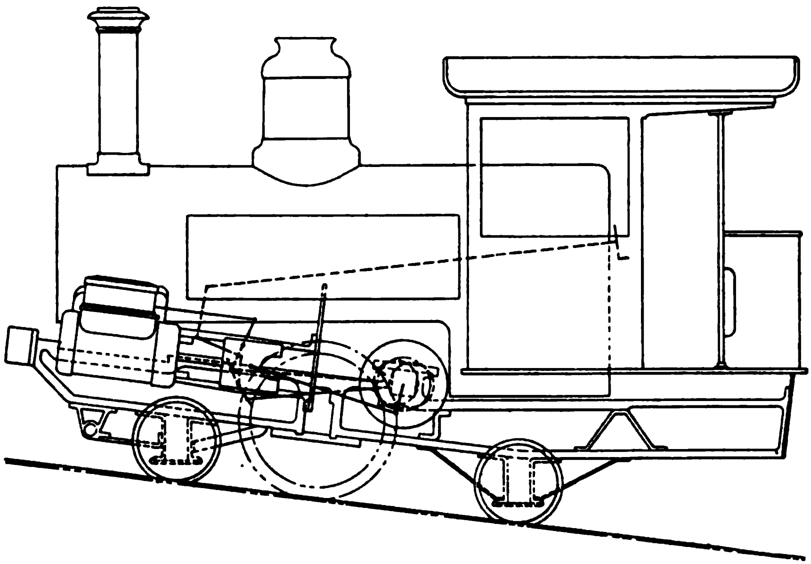
Egurgito . . .
Egypciaco . .
Egypius . . .
Egyptiaque . .
Egyptien . . .
Egyptology . .
Ehamote . . .
Ehebett . . .
Ehebruch . .
Ehebund . . .
Ehefrau . . .
Ehegatte . . .
Ehegeld . . .
Ehegemahl . .
Ehegenosse . .
Ehegericht . .
Ehegespons . .
Ehegestern . .
Ehehaelfte . .
Ehejoch . . .
Eheklage . . .
Eheleben . . .
Eheleute . . .
Eheliebe . . .
Ehelos . . . .
Ehemals . . .
Ehemann . .
Eheordnung . .
Ehepaar . . .
Ehepfand . . .
Eherecht . . .
Ehering . . .
Eheringen . .
Ehern . . . .
Eheschatz . .
Eheschmied . .
Eheschuld . .
Ehesegen . . .
Ehestifter . . .
Ehestunde . .
Ehevater . . .

Ehevogt . . .
Eheweib . . .
Ehewunsch . .
Ehodum . . .
Ehontement . .
Ehoupper . . .
Ehrbarer . . .
Ehrenamt . .
Ehrenbahn . .
Ehrenbett . . .
Ehrenbild . . .
Ehrenbogen . .
Ehrengabe . .
Ehrengift . . .
Ehrengrab . .
Ehrengruss . .
Ehrenhaft . .
Ehrenkampf .
Ehrenkerze . .
Ehrenkette . .
Ehrenkranz . .
Ehrenkreuz . .
Ehrenkrone . .
Ehrenlied . .
Ehrenlohn . .
Ehrenluege . .
Ehrenmahl . .
Ehrenmann . .
Ehrenmusik . .
Ehrenpaar . .
Ehrenplatz . .
Ehrenpreis . .
Ehrenpunkt . .
Ehrenrauch . .
Ehrenrecht . .
Ehrenreim . .
Ehrenrock . .

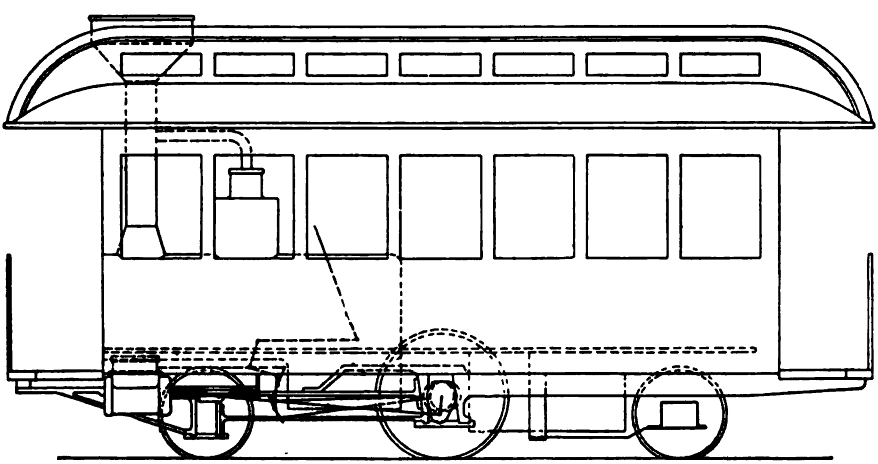
TYPES OF LOCOMOTIVES

IN order to aid in understanding the class designations more readily, the different types of engines manufactured at these Works, with the class designations of each type, and the kind of service for which they are specially designed or adapted, are shown by line illustrations, in the following pages.

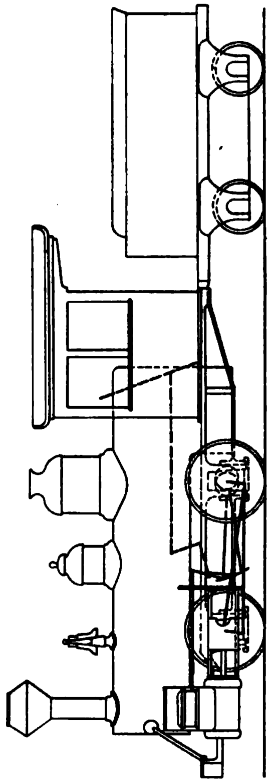
Reference is made also to the explanation of the system of classification adopted, which is to be found on pages 107 to 109.



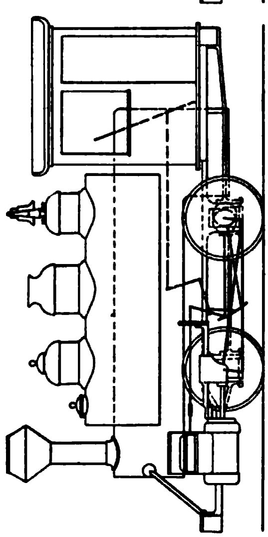
5 A (RACK RAIL TYPE).
MOUNTAIN SERVICE.



6 B.
INSPECTION SERVICE.

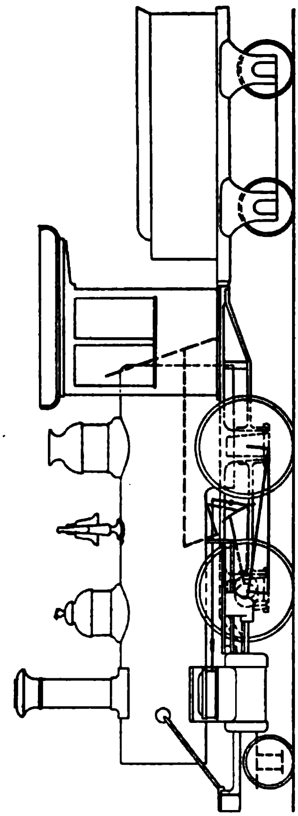


4 C WITH TENDER.

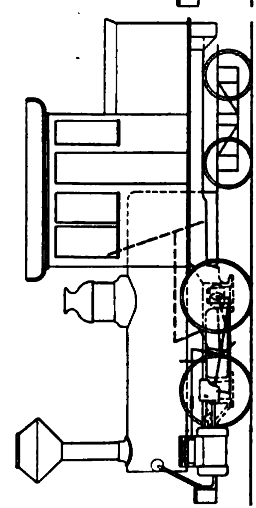


4 C TANK ON BOILER.

SWITCHIIING SERVICE.

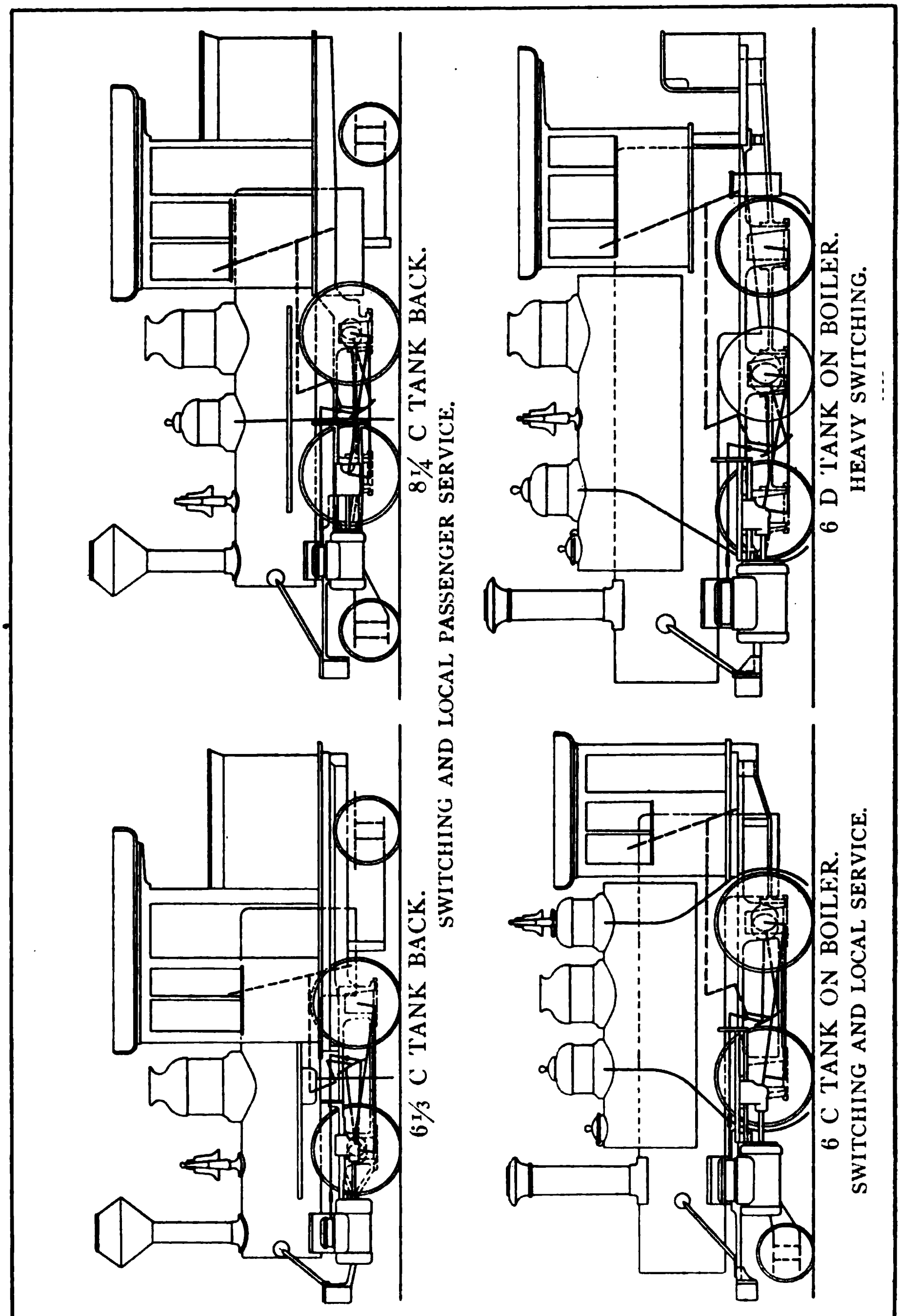


6 C WITH TENDER.



8⅓ C TANK BACK.

SWITCHING AND LOCAL SERVICE.



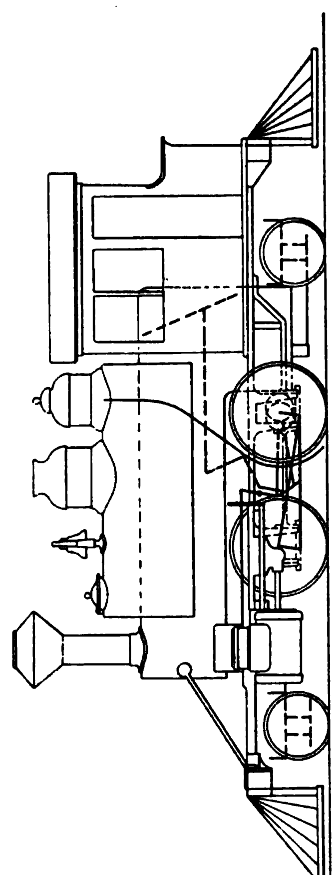
6⅓ C TANK BACK.

8¼ C TANK BACK.

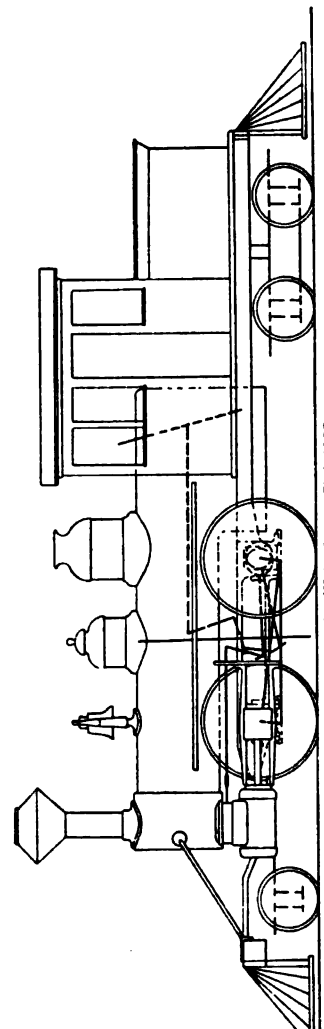
SWITCHING AND LOCAL PASSENGER SERVICE.

6 C TANK ON BOILER.
SWITCHING AND LOCAL SERVICE.

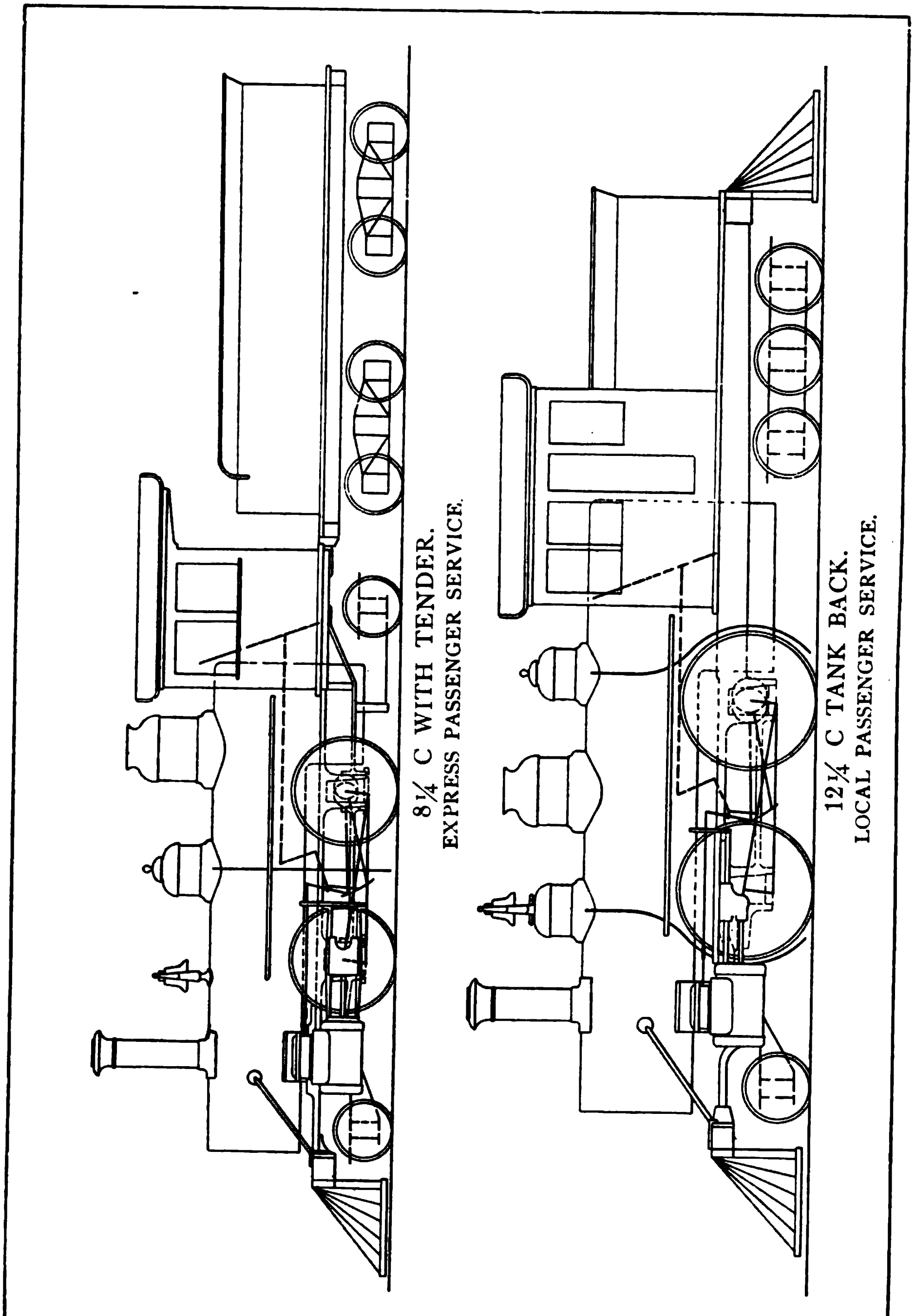
6 D TANK ON BOILER.
HEAVY SWITCHING.



8¼ C TANK ON BOILER.
LOCAL PASSENGER SERVICE.

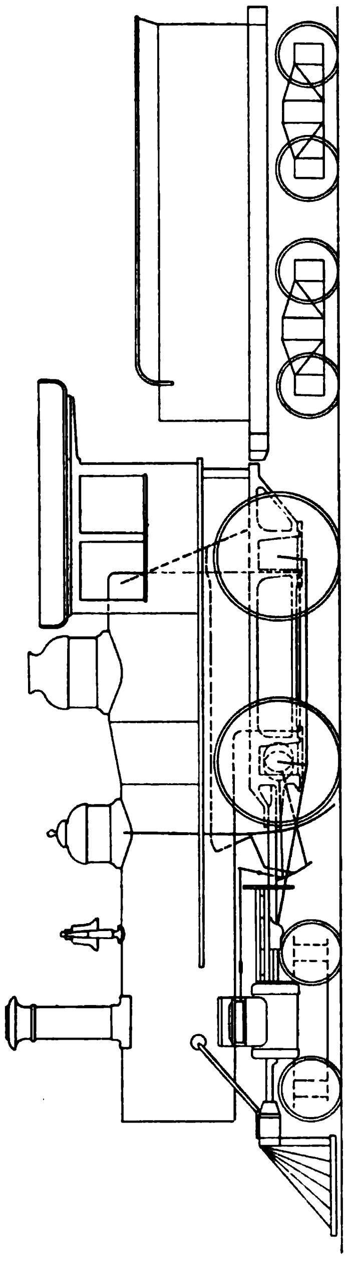


10¼ C TANK BACK.
LOCAL PASSENGER SERVICE.

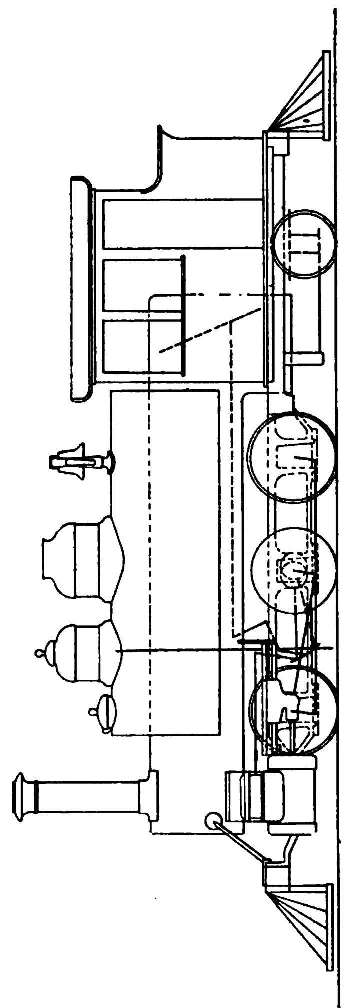


8¼ C WITH TENDER.
EXPRESS PASSENGER SERVICE.

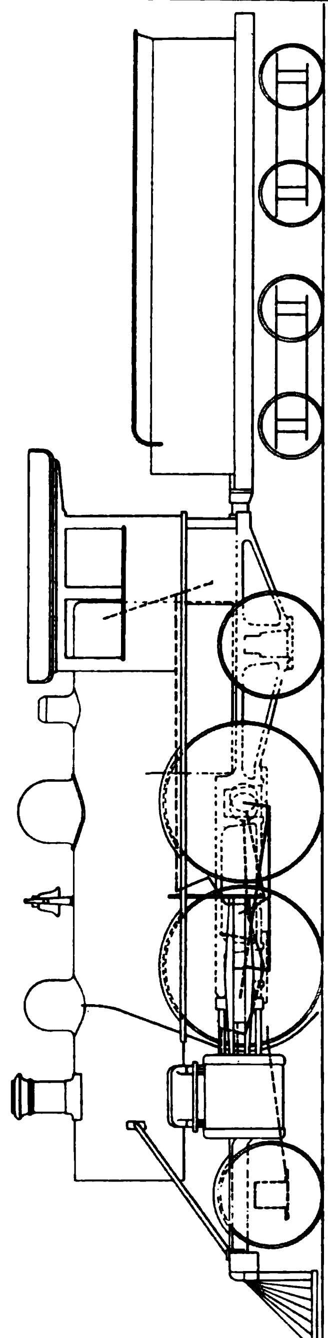
12¼ C TANK BACK.
LOCAL PASSENGER SERVICE.



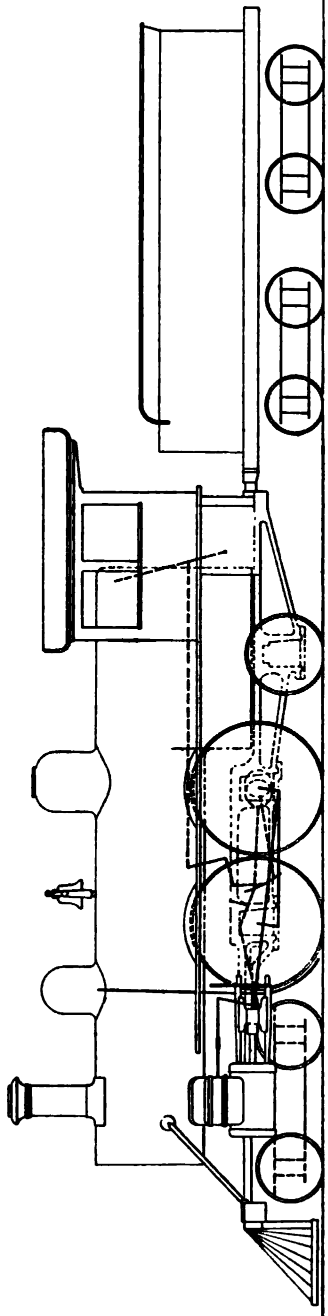
8 C (AMERICAN TYPE).
EXPRESS PASSENGER SERVICE.



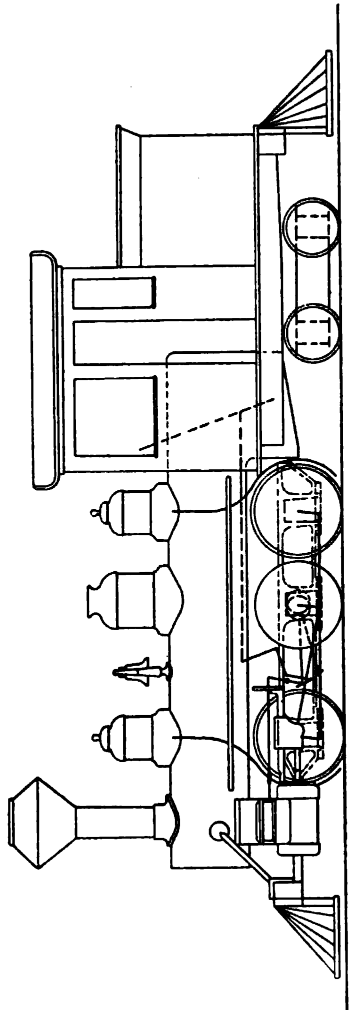
8⅓ D TANK ON BOILER.
HEAVY SWITCHING AND LOCAL FREIGHT SERVICE.



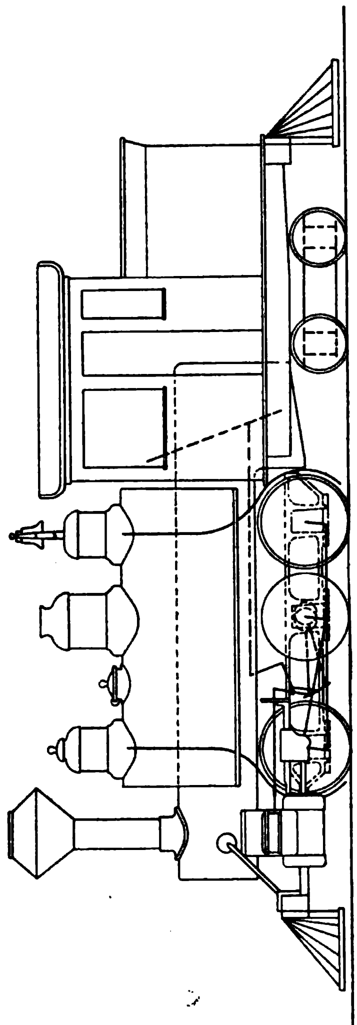
$8\frac{1}{4}$ C (COLUMBIA TYPE).
HIGH SPEED PASSENGER SERVICE.



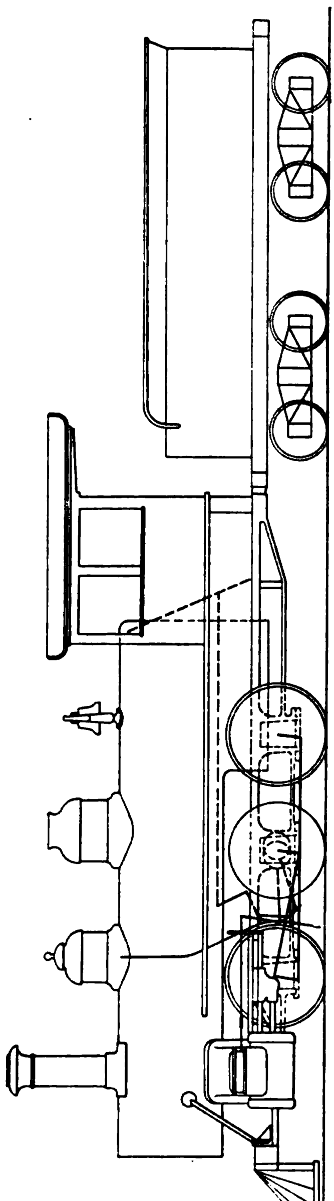
$10\frac{1}{4}$ C (ATLANTIC TYPE).
HIGH SPEED PASSENGER SERVICE.



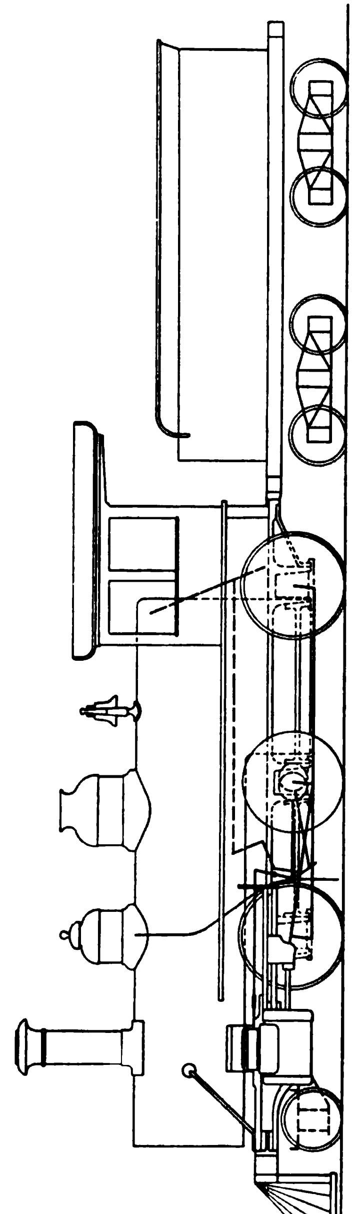
10⅓ D TANK BACK.
HEAVY SWITCHING AND LOCAL FREIGHT SERVICE.



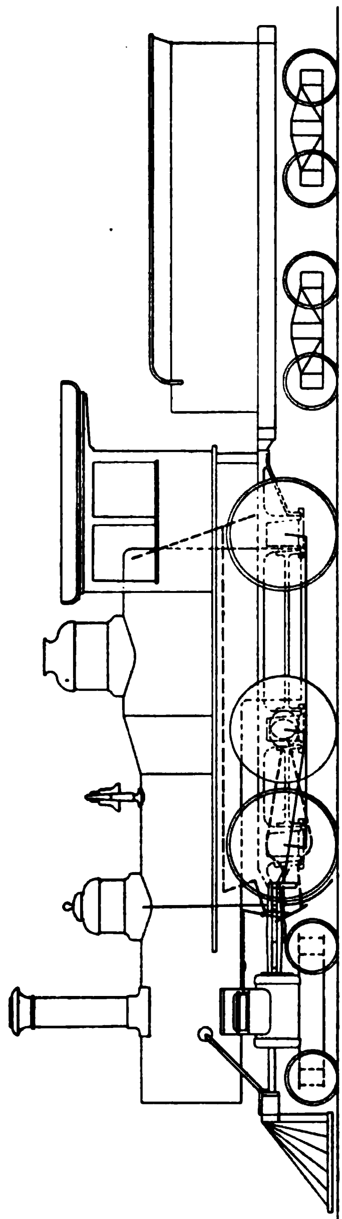
10⅓ D TANK BACK AND ON BOILER.
HEAVY SWITCHING AND LOCAL FREIGHT SERVICE.



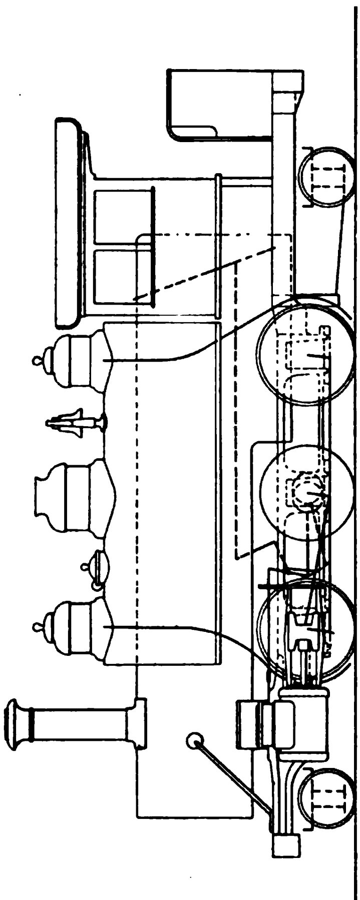
6 D WITH TENDER.
HEAVY SWITCHING SERVICE.



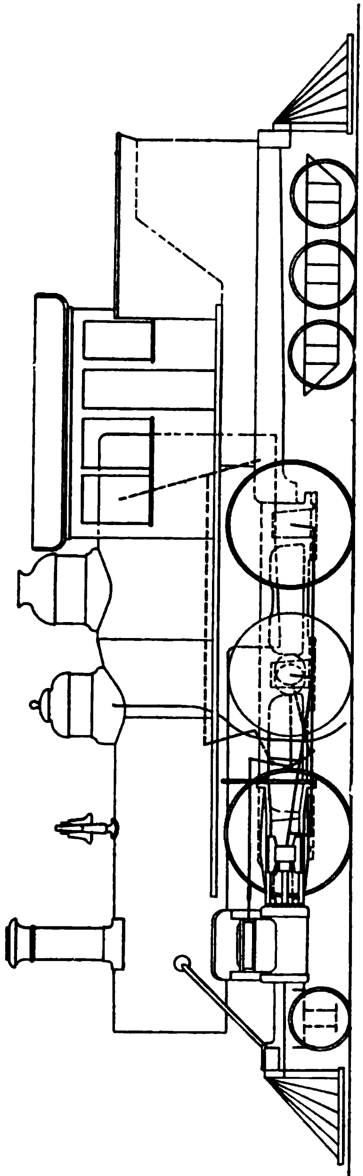
8 D MOGUL.
FREIGHT SERVICE.



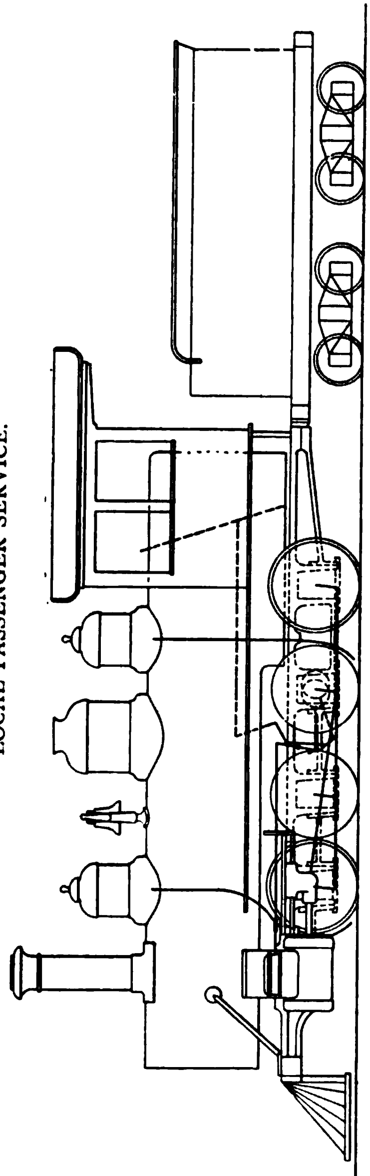
10 D TEN WHEELER.
FAST FREIGHT AND PASSENGER SERVICE.



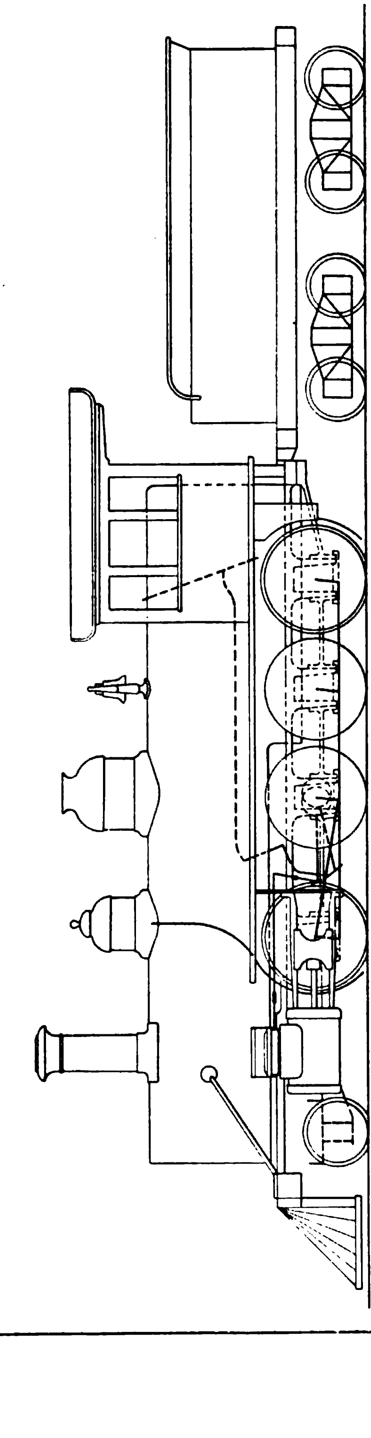
10¼ D TANK ON BOILER.
HEAVY SWITCHING SERVICE.



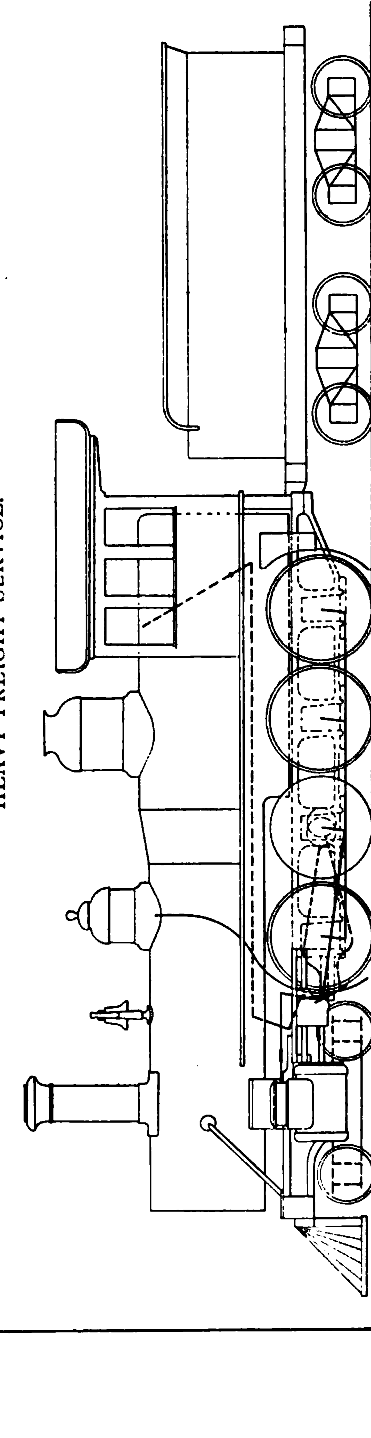
14¼ D TANK BACK.
LOCAL PASSENGER SERVICE.



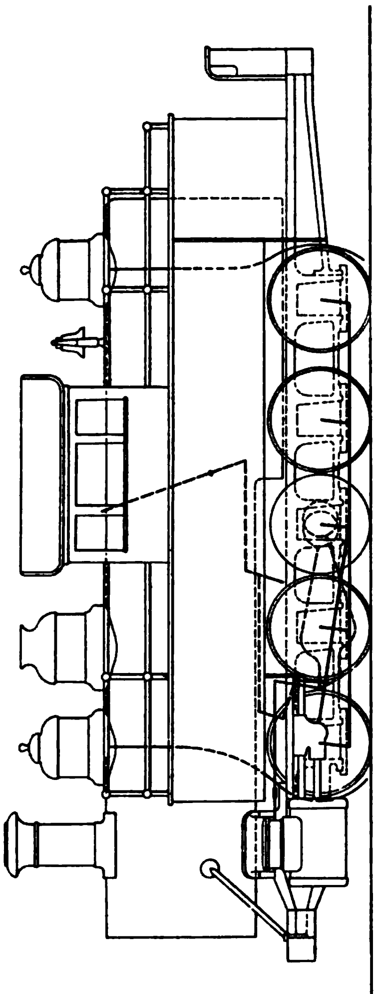
8 E.
HEAVY FREIGHT SERVICE.



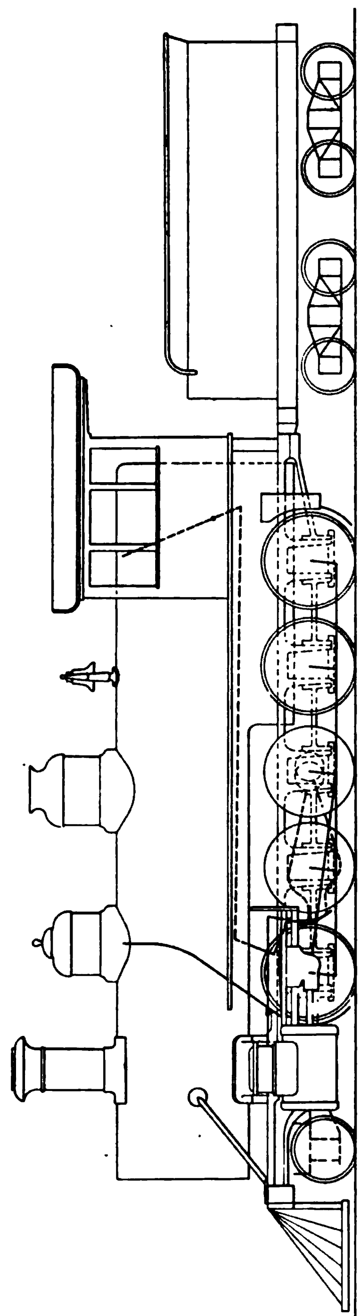
10 E CONSOLIDATION.
HEAVY FREIGHT SERVICE.



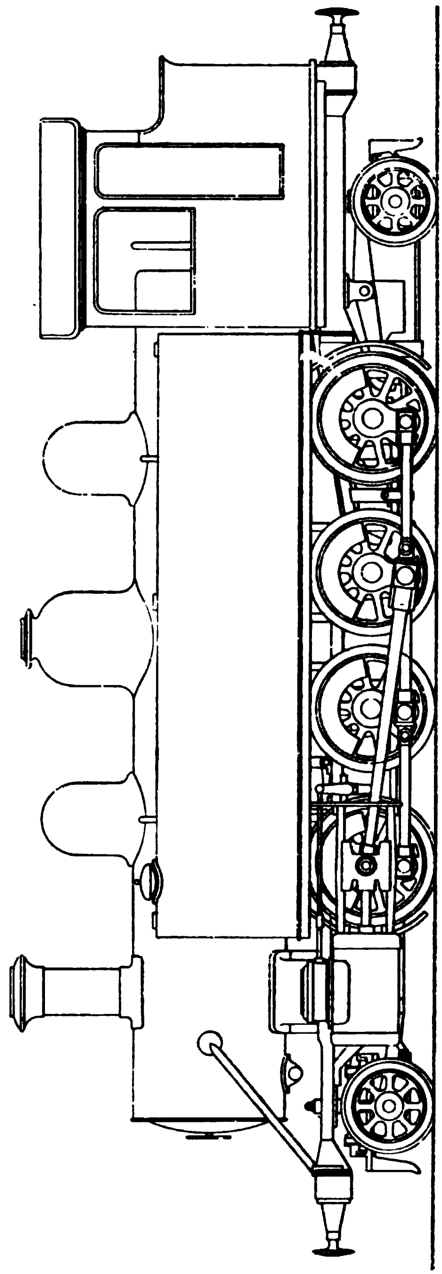
12 E.
HEAVY FREIGHT SERVICE.



10 F TANK ON BOILER.
HEAVY SWITCHING SERVICE.



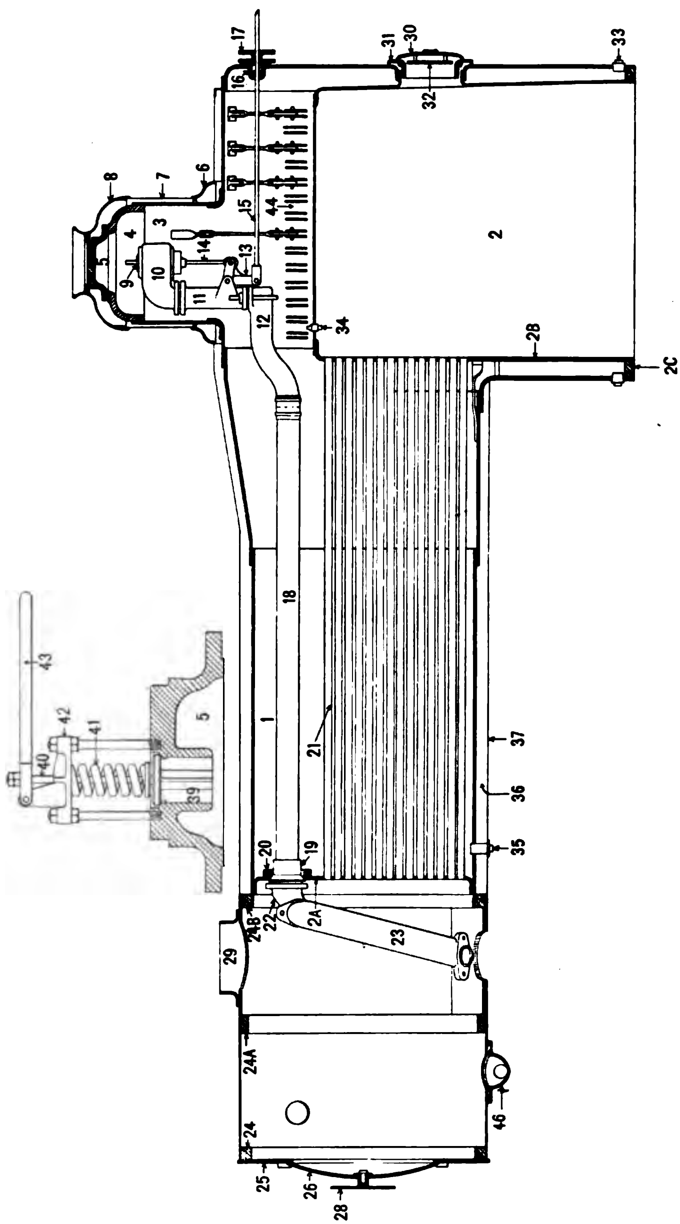
12 F DECAPOD.
HEAVY FREIGHT SERVICE.



12¼ E TANK.
CAN ALSO BE USED WITH TENDER.

ILLUSTRATED PLATES.

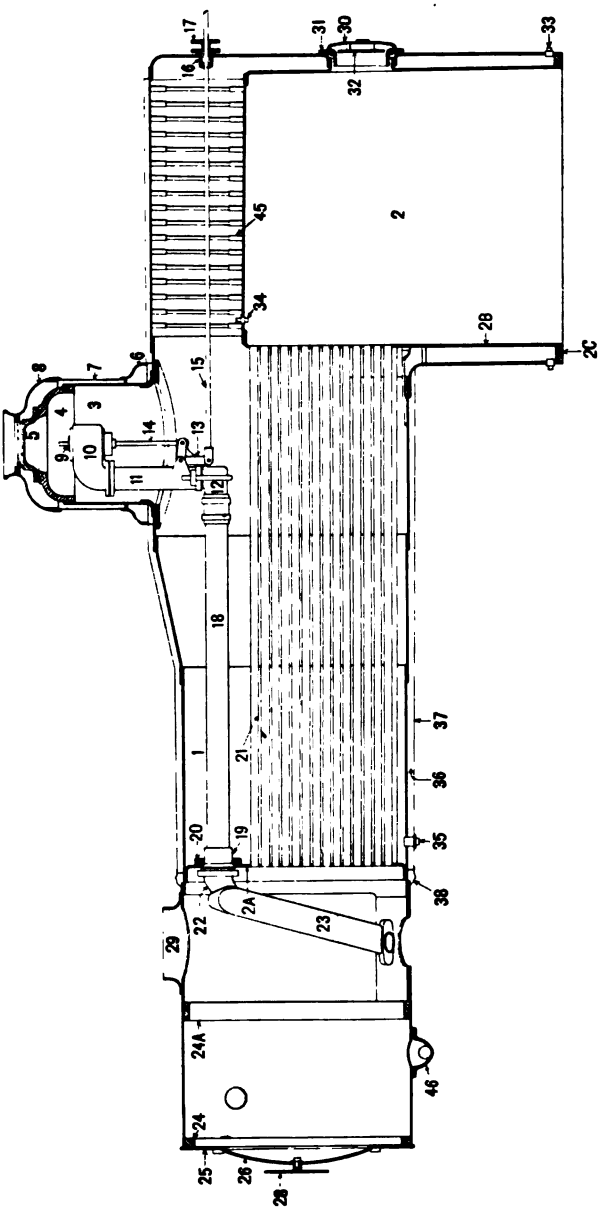
Plate I.



CROWN BAR TYPE.

Plate 2.

RADIAL STAY TYPE.



BOILER AND ATTACHMENTS.

Plates 1 and 2. EHRENRUF.

Ehrensaal . . .	1.	Boiler.			
Ehrensitz	2.	Fire Box.			
Ehrensoak . . .	2A.	Front Tube Sheet.			
Ehrensob	2B.	Firebox " "			
Ehrensoen . . .	2C.	Water Space Frame.			
Ehrensold . . .	3.	Dome.			
Ehrenstamm . .	3.	"	Ring.		
Ehrenstufe . . .	5.	"	Cap.		
Ehrentag	6.	"	Base.		
Ehrentanz . . .	7.	"	Casing.		
Ehrenthat . . .	8.	"	Cover.		
Ehrentheil . . .	9.	Throttle Valve.			
Ehrenthron . .	10.	"	"	Box.	
Ehrentitel . . .	11.	"	Pipe.		
Ehrentod	12.	"	"	Elbow.	
Ehrenvoll	13.	"	Valve Crank.		
Ehrenwache . .	14.	"	"	Rod.	
Ehrenwein . . .	15.	"	"	Stem.	
Ehrenwort . . .	16.	"	Stuffing Box.		
Ehrenzeit	17.	"	"	"	Gland.
Ehretia	18.	Dry Pipe.			
Ehrfurcht	19.	"	Front End.		
Ehrgeiz	20.	"	Ring on Tube Sheet.		
Ehrgeizig	21.	Tubes.			
Ehrlich	22.	Double Cone.			
Ehrliebig	23.	Steam Pipes, R and L.			
Ehrsucht	24.	Smoke Box Ring Front.			
Ehrtrieb	24A.	"	"	"	Middle.
Eiagada	24B.	"	"	"	Back.

Eibisch	25.	Smoke Box Front.
Eiceti	26.	" " Door.
Eichapfel . . .	27.	" " " Liner.
Eichelganz . .	28.	Number Plate.
Eichelmast . .	29.	Smoke Stack Base.
Eichelmaus . .	30.	Fire Door.
Eichelnapf . .	31.	" " Frame.
Eichen	32.	" " Liner.
Eichenast . . .	33.	Corner Plug.
Eichenhain . .	34.	Fusible "
Eichenlaub . .	35.	Waist "
Eichenlohe . .	36.	Lagging.
Eichenmoos . .	37.	Jacket.
Eichennest . .	38.	Smoke Box Band.
Eichenreis . . .	39.	Safety Valve.
Eichenrose . .	40.	" " Stem.
Eichenwald . .	41.	" " Spring.
Eichhase . . .	42.	" " " Cap.
Eichhorn . . .	43.	Relief Lever.
Eichkatze . . .	44.	Crown Bar.
Eichkranz . . .	45.	Staybolt.
Eichnuss . . .	46.	Spark Ejector.

In ordering steam pipes (No 23), it will be necessary to specify the side, if both are not wanted.

Smoke stack base (No. 29), while shown in one piece on this plate, is frequently made in two parts, as shown on Plate 31, and either part can be had by referring to the latter plate. See Plate 4 for steel base.

Jacket bands are not given a number in this list, as they are easily designated without.

In many cases patented valves are used instead of the safety valve shown on this plate. In ordering, state whether valve is wanted with or without relief lever.

Plate 3.

Fig. 1

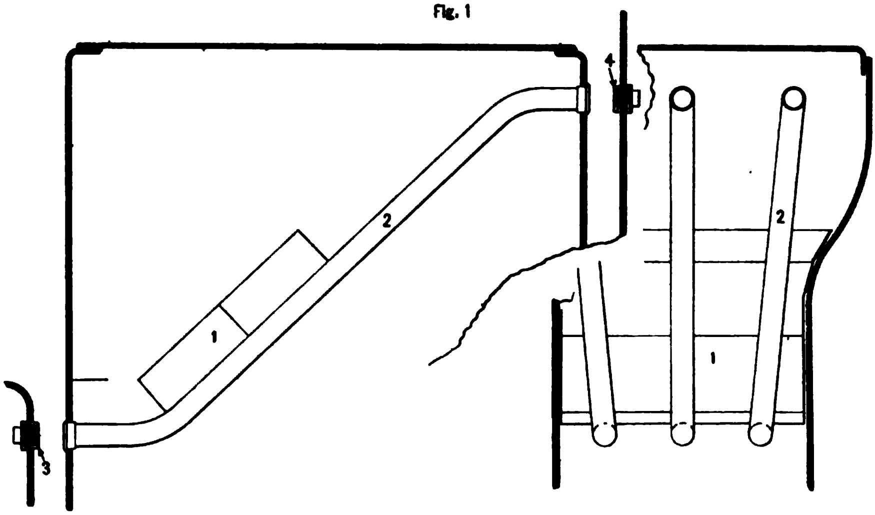
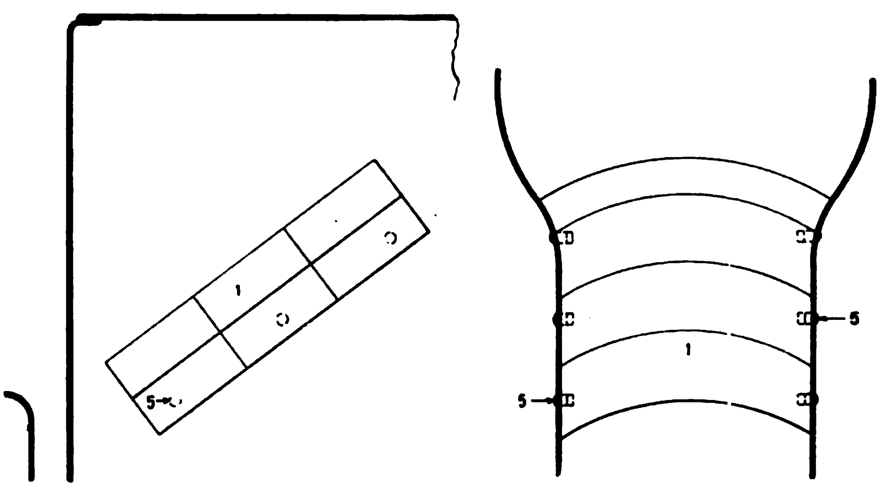


Fig. 2



ARRANGEMENT OF FIRE BRICKS IN FIRE BOX.

Plate 3. EICHOCHS.

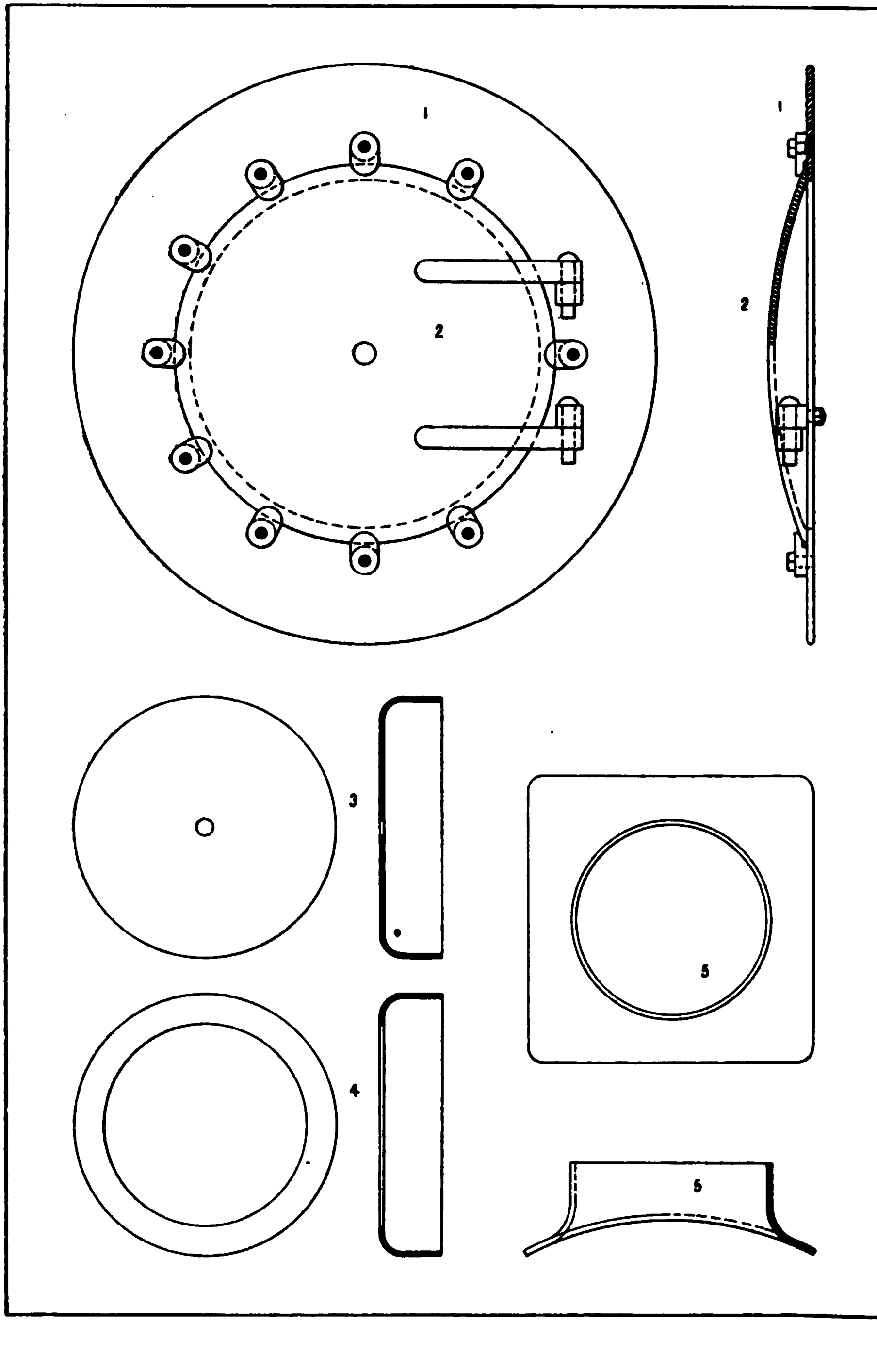
Fig. I.—Bricks supported on Tubes.

Eichstab	1.	Fire	Brick.			
Eichtraube . .	2.	"	"	Tube.		
Eicimus	3.	"	"	"	Plug, Front.	
Eidechse. . . .	4.	"	"	"	"	Back.

Fig. II.—Bricks supported on Studs.

Eiderbett . . . 5. Fire Brick Stud.

Plate 4.



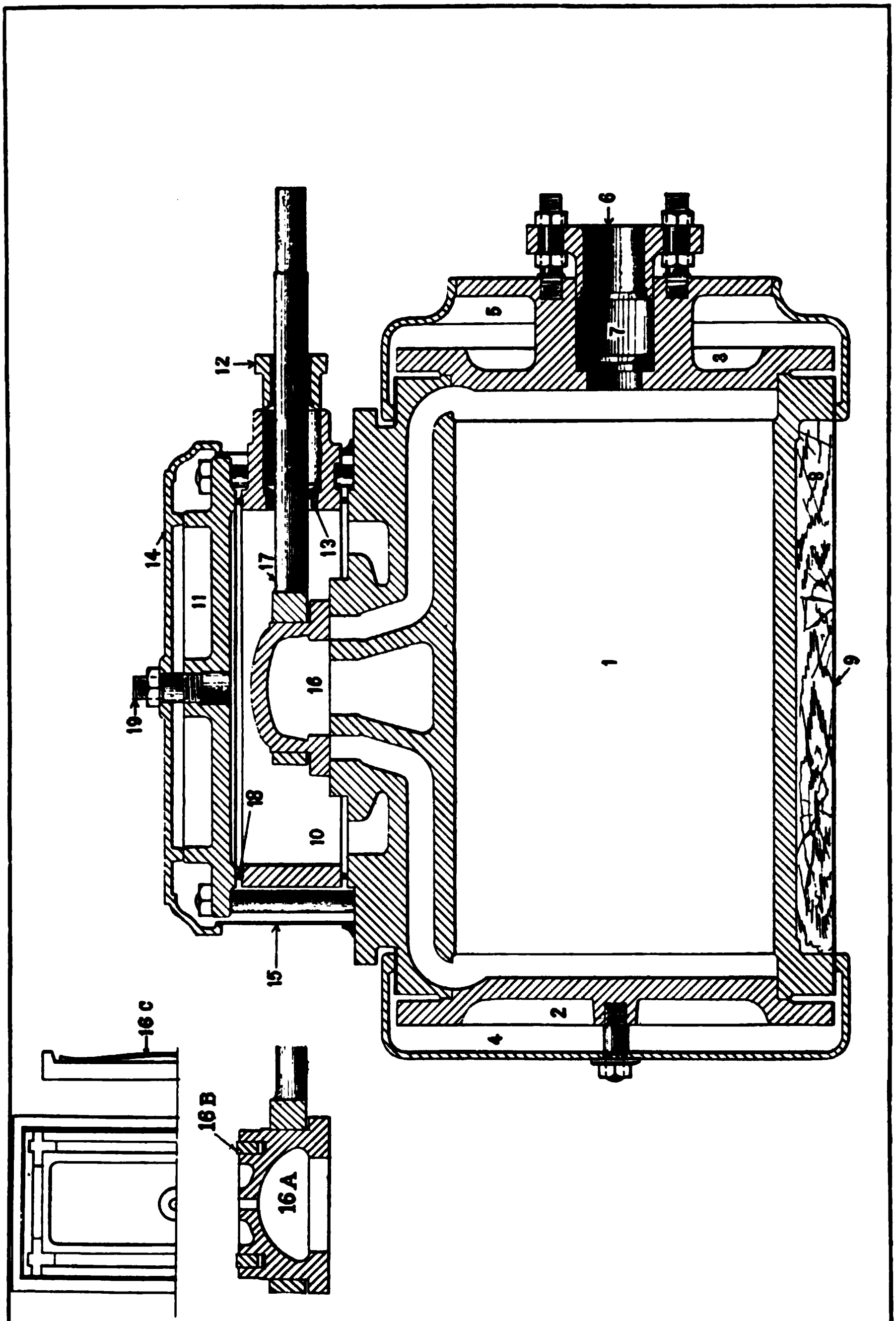
PRESSED STEEL SMOKE BOX FRONT, CYLINDER HEAD COVER AND STACK BASE.

Plate 4. EIDERDAUNE.

Eiderdons . . .	1.	Smoke Box Front.
Eidereend . . .	2.	" " Door.
Eidergans . . .	3.	Cylinder Head Cover, Front.
Eidervogel . .	4.	" " " Back.
Eidesmann . .	5.	Stack Base.

Plates 1 and 2 show cast iron smoke box fronts and stack bases, and Plate 5 cast iron cylinder head covers. These have in recent years been superseded on many railroads by similar parts made of steel sheets pressed while hot in dies giving them the required forms. They are much stronger, and consequently more durable than cast iron, present a simple, neat appearance, and in many cases when injured can be brought back to their original shape.

Plate 5.



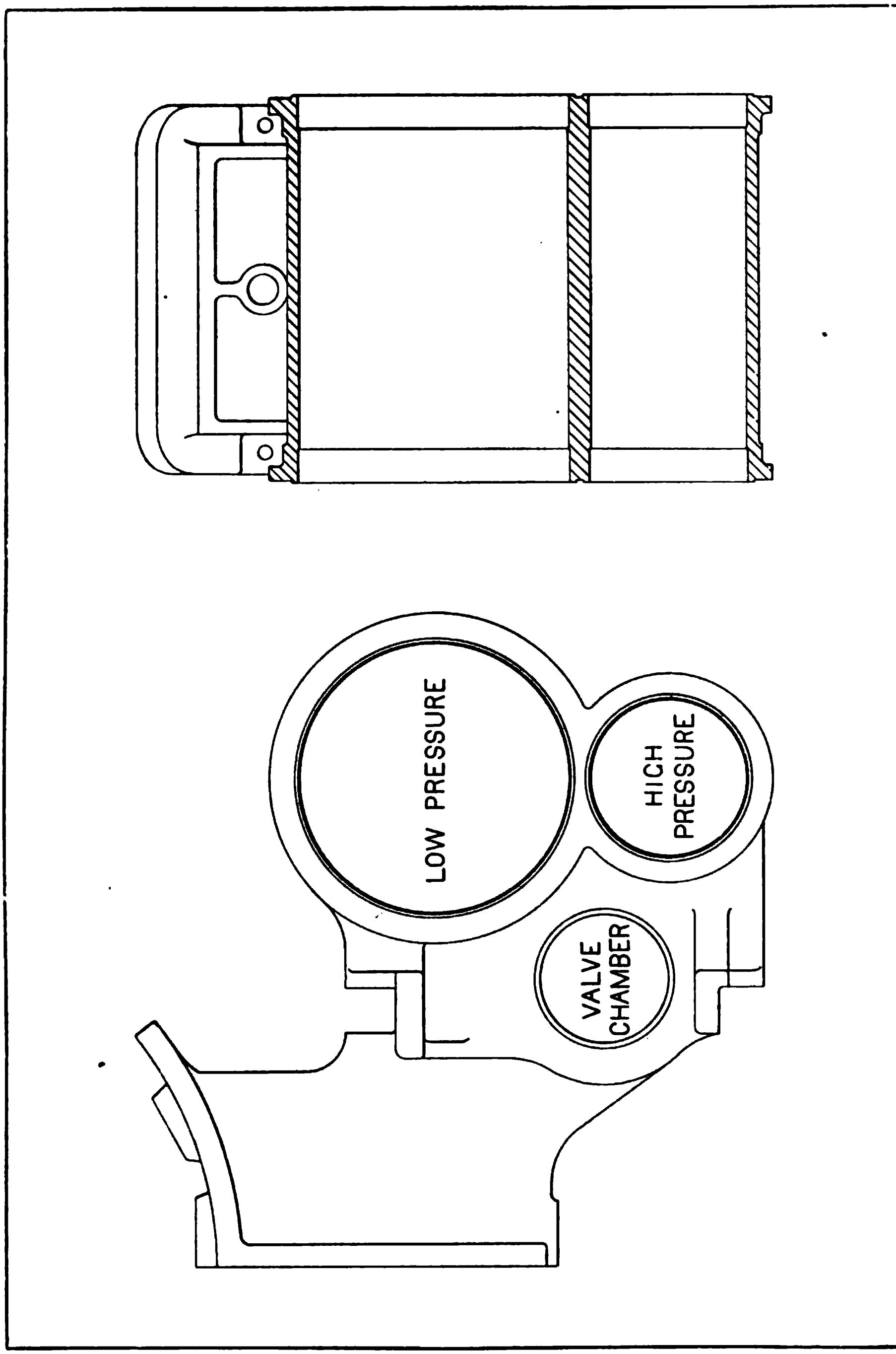
SINGLE EXPANSION CYLINDER, STEAM CHEST AND ATTACHMENTS.

Plate 5. EIDFEST.

Eidgenosse .	1.	Cylinder.
Eidgesell . .	2.	Front Head.
Eidiertje . . .	3.	Back "
Eidograph . .	4.	Front Casing Cover.
Eidolon . . .	5.	Back " "
Eidopsare . .	6.	Cylinder Gland, R. & L.
Eidothee . .	7.	" " Bottom Ring.
Eidotrope . .	8.	Wood Lagging.
Eierapfel . .	9.	Casing.
Eierbier . . .	10.	Steam Chest.
Eierblume . .	11.	" " Cap.
Eierbrot . . .	12.	" " Gland.
Eierdooier . .	13.	" " " Bottom Ring.
Eierdoop . . .	14.	" " Casing Cover.
Eierdopjes . .	15.	" " Casing.
Eiergerste . .	16.	" " Valve.
Eierghant . .	16A.	" " " Balanced Pattern.
Eiergome . .	16B.	" " " Packing Strips.
Eierhorst . .	16C.	" " " " Springs.
Eierkanaal .	17.	" " " Yoke.
Eierketel . .	18.	" " Joint.
Eierkoek . .	19.	" " Oil Pipe Stem.

If a single cylinder, head, gland, or steam chest is ordered, the side required for should be specified.

Plate 6.



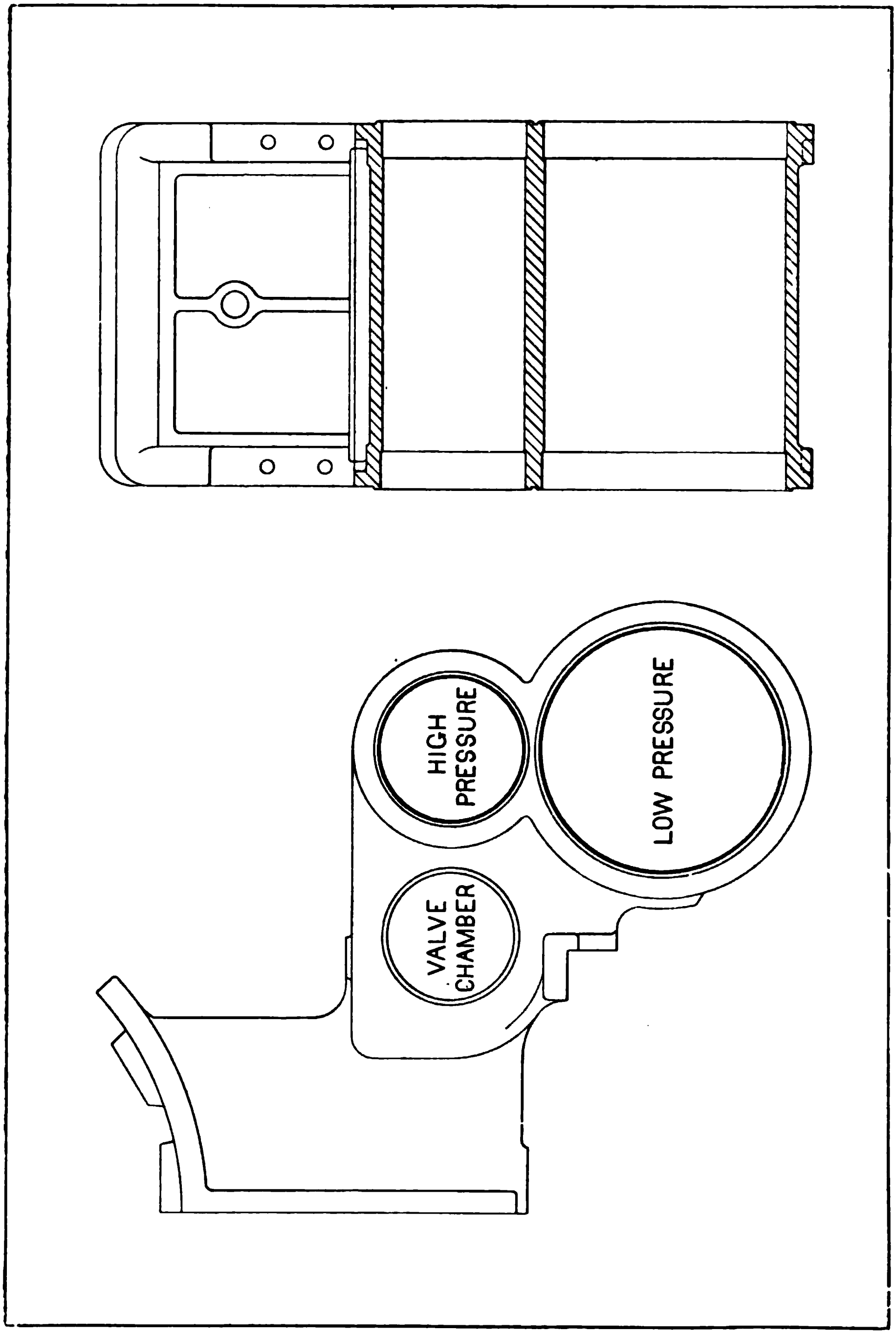
BALDWIN COMPOUND CYLINDERS (FOUR CYLINDER—VAUCLAIN SYSTEM).

Plate 6. EIERKOEKJE.

Baldwin Compound Cylinders with Low Pressure Cylinder above High Pressure, showing one side of locomotive.

The High and Low Pressure Cylinders are cast in one piece.

Plate 7.



BALDWIN COMPOUND CYLINDERS (FOUR CYLINDER—VAUCLAIN SYSTEM).

Plate 7. EIERKOOPER.

Baldwin Compound Cylinders with High Pressure Cylinder above Low Pressure, showing one side of locomotive.

The High and Low Pressure Cylinders are cast in one piece.

Plate 8.

DIAGRAM SHOWING COURSE OF STEAM IN FOUR CYLINDER COMPOUND LOCOMOTIVE.

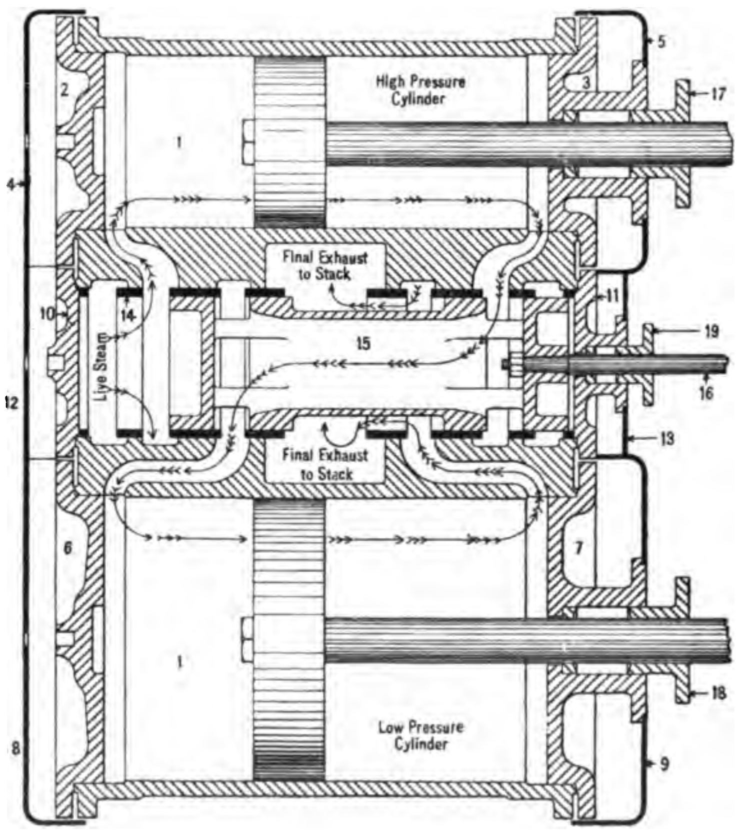


DIAGRAM OF BALDWIN COMPOUND CYLINDERS (VAUCLAIN SYSTEM) SHOWING THE COURSE OF STEAM IN THE CYLINDERS AND VALVE CHAMBER.

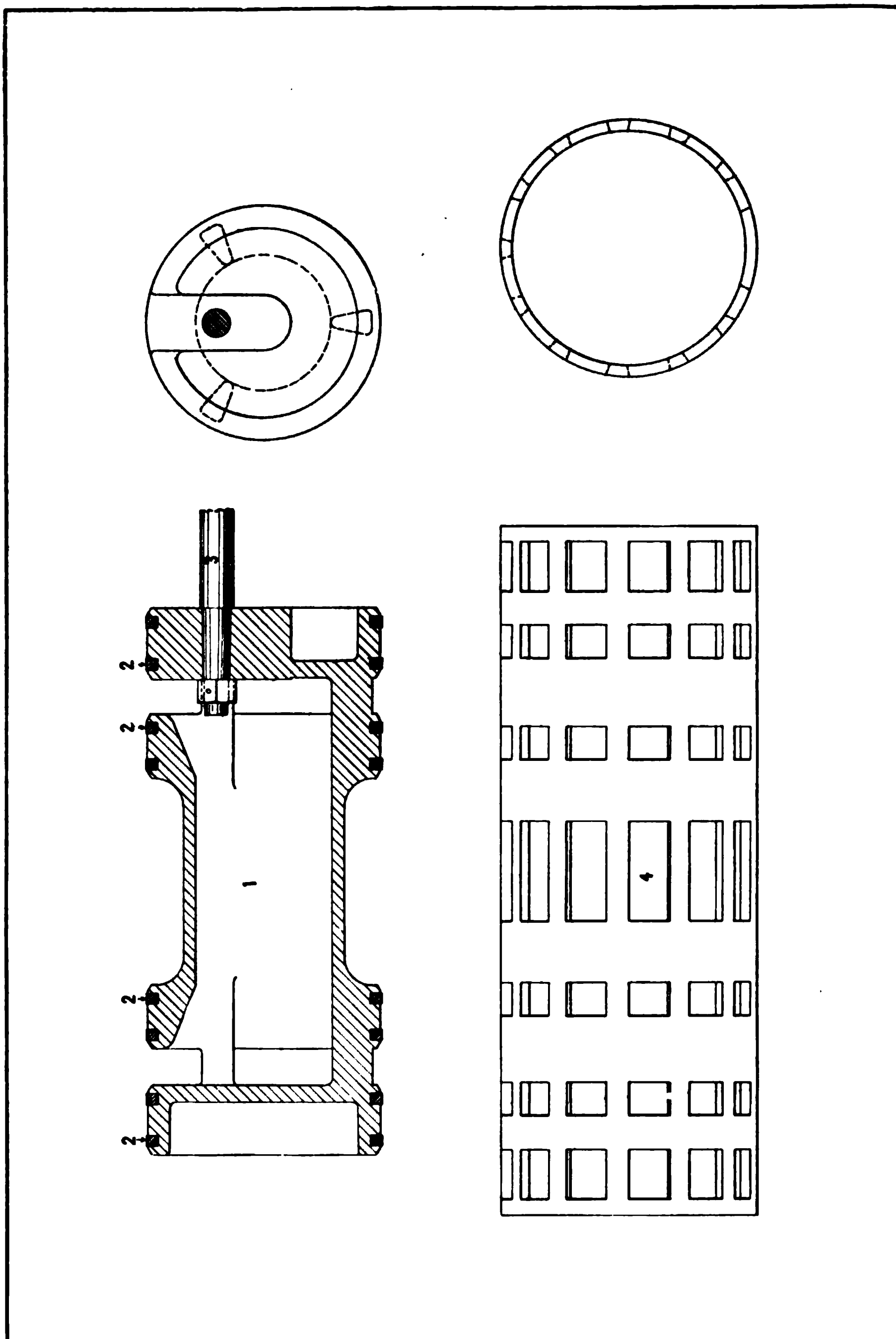
Plate 8. EIERKRAMER.

Eierkugel .	1. Cylinder.					
Eierlage . .	2. High Pressure	Front	Cylinder	Head.		
Eierlijst . .	3. "	"	Back	"	"	
Eiermand .	4. "	"	Front	"	" Casing Cover.	
Eiermarkt .	5. "	"	Back	"	" " "	
Eiermelk . .	6. Low	"	Front	"	"	
Eiermilch .	7. "	"	Back	"	"	
Eiermuss . .	8. "	"	Front	"	" Casing Cover.	
Eiernapf . .	9. "	"	Back	"	" " "	
Eiernetjes .	10. Front Valve Chamber Head.					
Eiernudel .	11. Back	"	"	"		
Eierpruim .	12. Front	"	"	"	Casing Cover.	
Eiersack . .	13. Back	"	"	"	" "	
Eiersalat . .	14. Valve Chamber Bushing.				(See Plate 9.)	
Eiersaus . .	15. Piston Valve.				" "	
Eierschaal .	16. " " Stem.				" "	
Eierschaum	17.*High Pressure Cylinder Gland.					
Eierschuit .	18.*Low	"	"	"		
Eierslak . .	19.*Valve Chamber Gland.					

If a single cylinder, head, casing cover, bushing, valve, stem, or gland is ordered, the side required for should be specified.

* Metallic Packing is used in all Stuffing Boxes of Compound Cylinders. (See Plate 79.)

Plate 9.



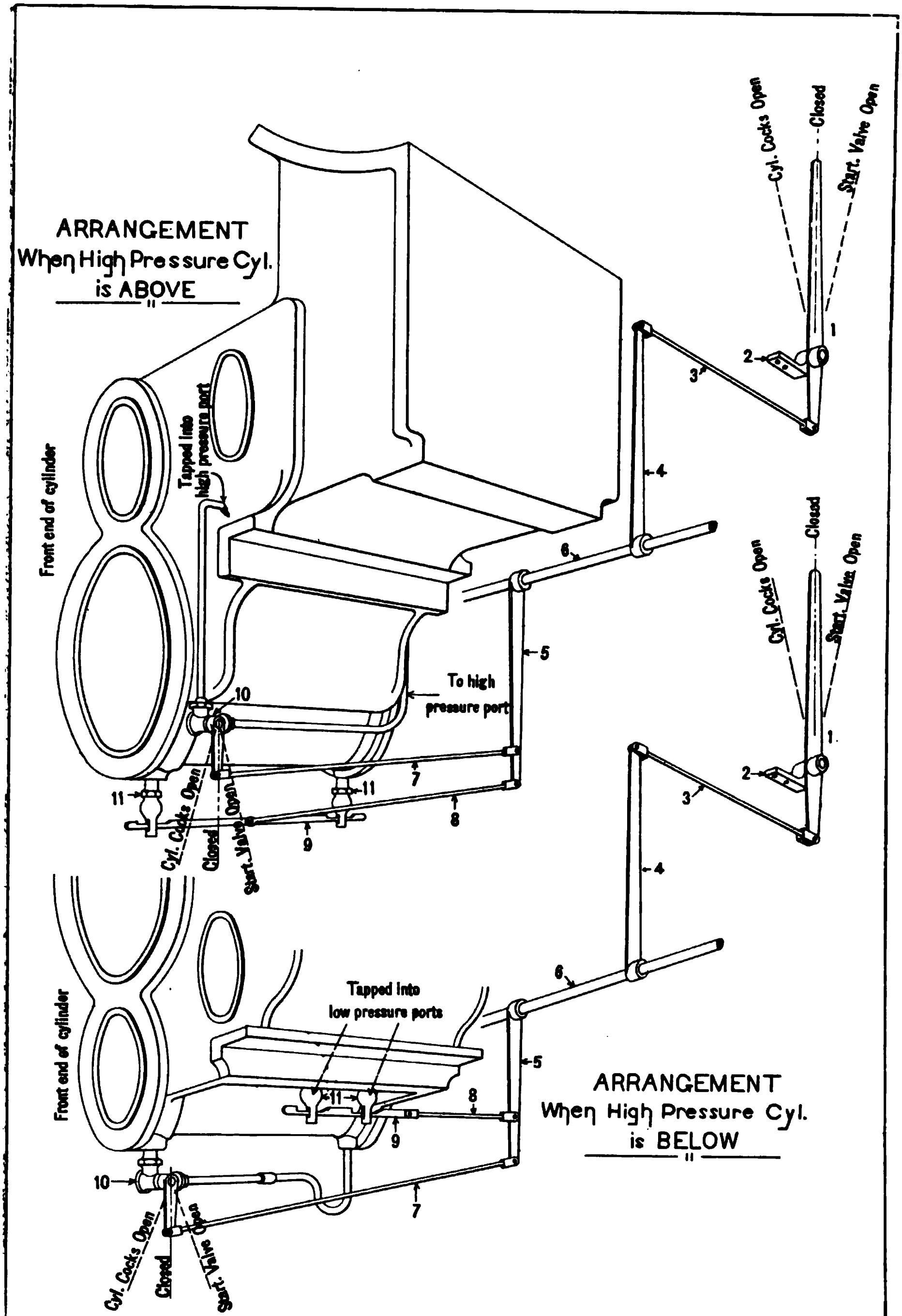
PISTON VALVE AND BUSHING FOR BALDWIN COMPOUND LOCOMOTIVE (VAUCLAIN SYSTEM).

Plate 9. EIERSOEP.

Eierspeise . . .	1.	Piston Valve.
Eierstab	2.	" " Packing Ring.
Eierstein . . .	3.	" " Stem.
Eierstock . . .	4.	Valve Chamber Bushing.

If a single valve, stem, or bushing is ordered, the side required for should be specified.

Plate 10.

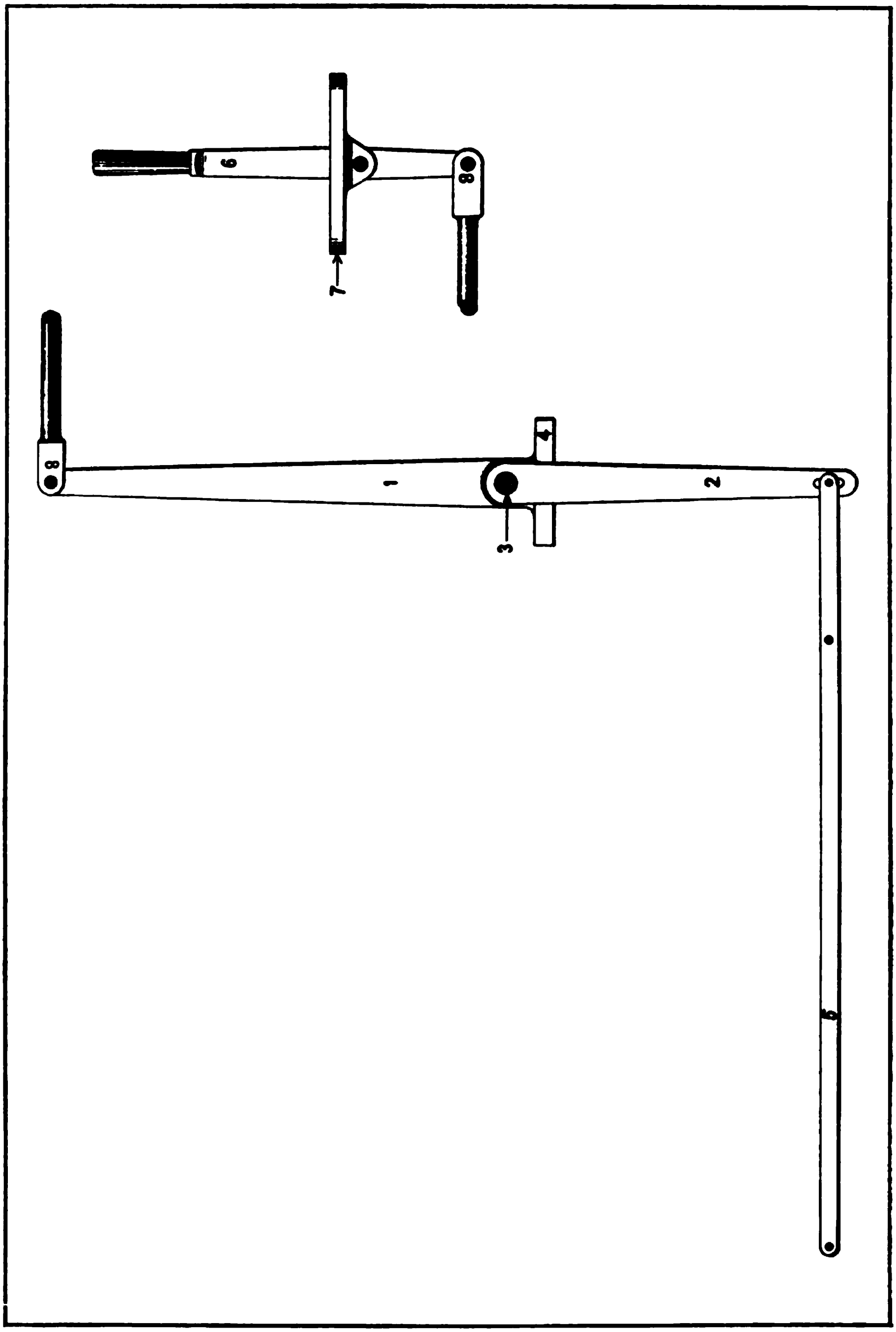

ARRANGEMENT
When High Pressure Cyl.
is ABOVE
Front end of cylinder
Tapped into high pressure port
To high pressure port
Cyl. Cocks Open
Closed
Start. Valve Open
1
2
3
4
5
6
7
8
9
10
11
Front end of cylinder
Tapped into low pressure ports
ARRANGEMENT
When High Pressure Cyl.
is BELOW

ARRANGEMENT OF STARTING VALVES AND CYLINDER COCKS FOR BALDWIN COMPOUND LOCOMOTIVE (VAUCLAIN SYSTEM).

Plate 10. EIERSTRUIF.

Eiersuppe . .	1.	Starting Valve Lever in Cab.
Eiertaart. . .	2.	" " " Fulcrum in Cab.
Eiertanz . . .	3.	" " Rod from Cab.
Eierteig . . .	4.	Upper Arm.
Eiertiegel . .	5.	Lower "
Eiertreter . .	6.	Shaft.
Eiervla	7.	Starting Valve Rod under Cylinder.
Eiervrouw. .	8.	Cylinder Cock " " "
Eierwasser .	9.	" " Strip.
Eierzins . . .	10.	Starting Valve.
Eifergeist . .	11.	Cylinder Cock.

Plate 11.

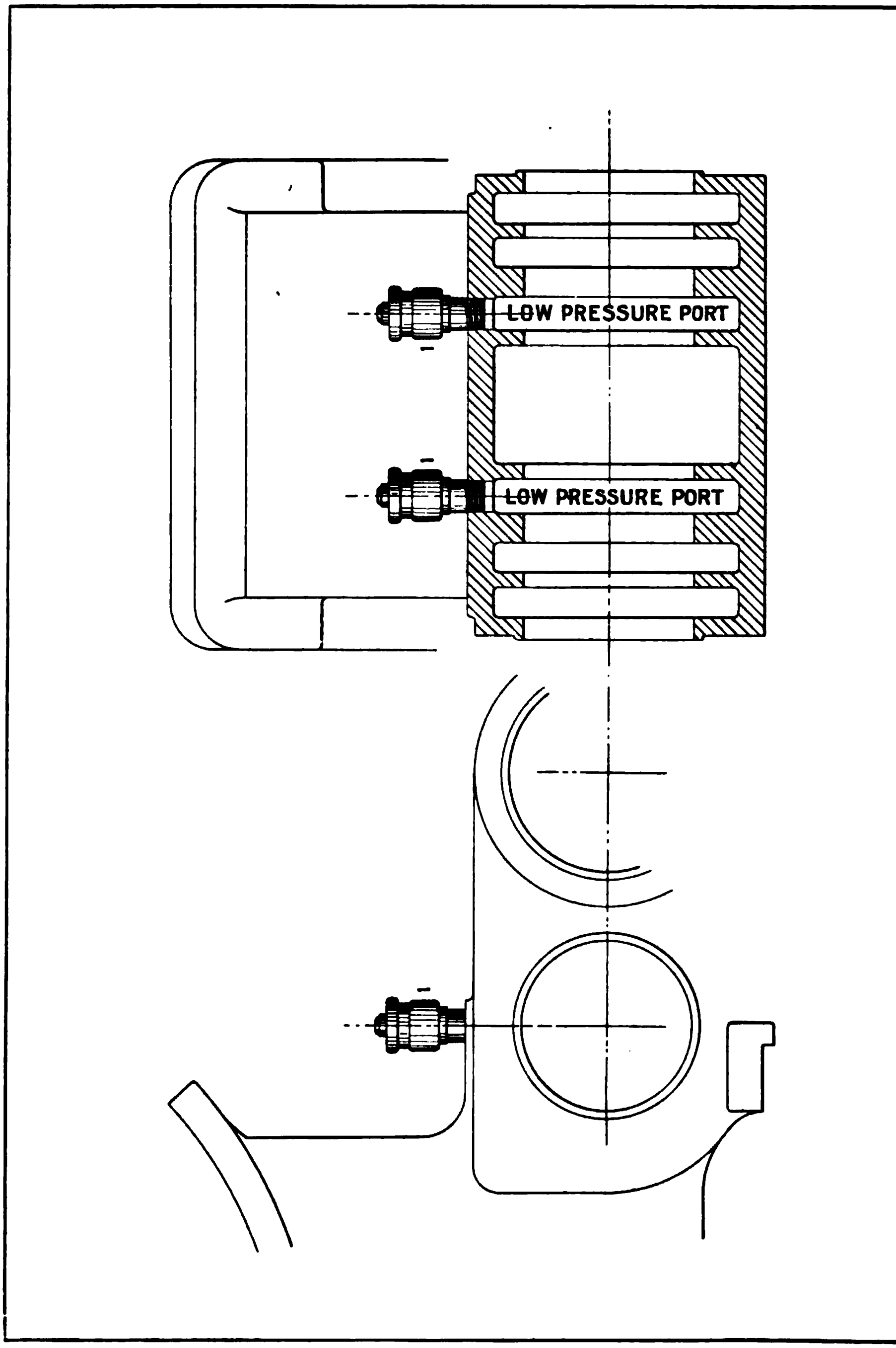


CYLINDER COCK WORK, FOR SINGLE EXPANSION LOCOMOTIVES.

Plate 11. EIFERHEISS.

Eiferliebe . . .	1.	Upper Arm.
Eifermuth . . .	2.	Lower "
Eifern	3.	Shaft.
Eiferopfer . . .	4.	" Bearing.
Eifersucht . . .	5.	Cock Strips.
Eifervoll	6.	Lever in Cab.
Eifrig	7.	" Fulcrum.
Eifriger	8.	Coupling Rod Jaws.

Plate 12.

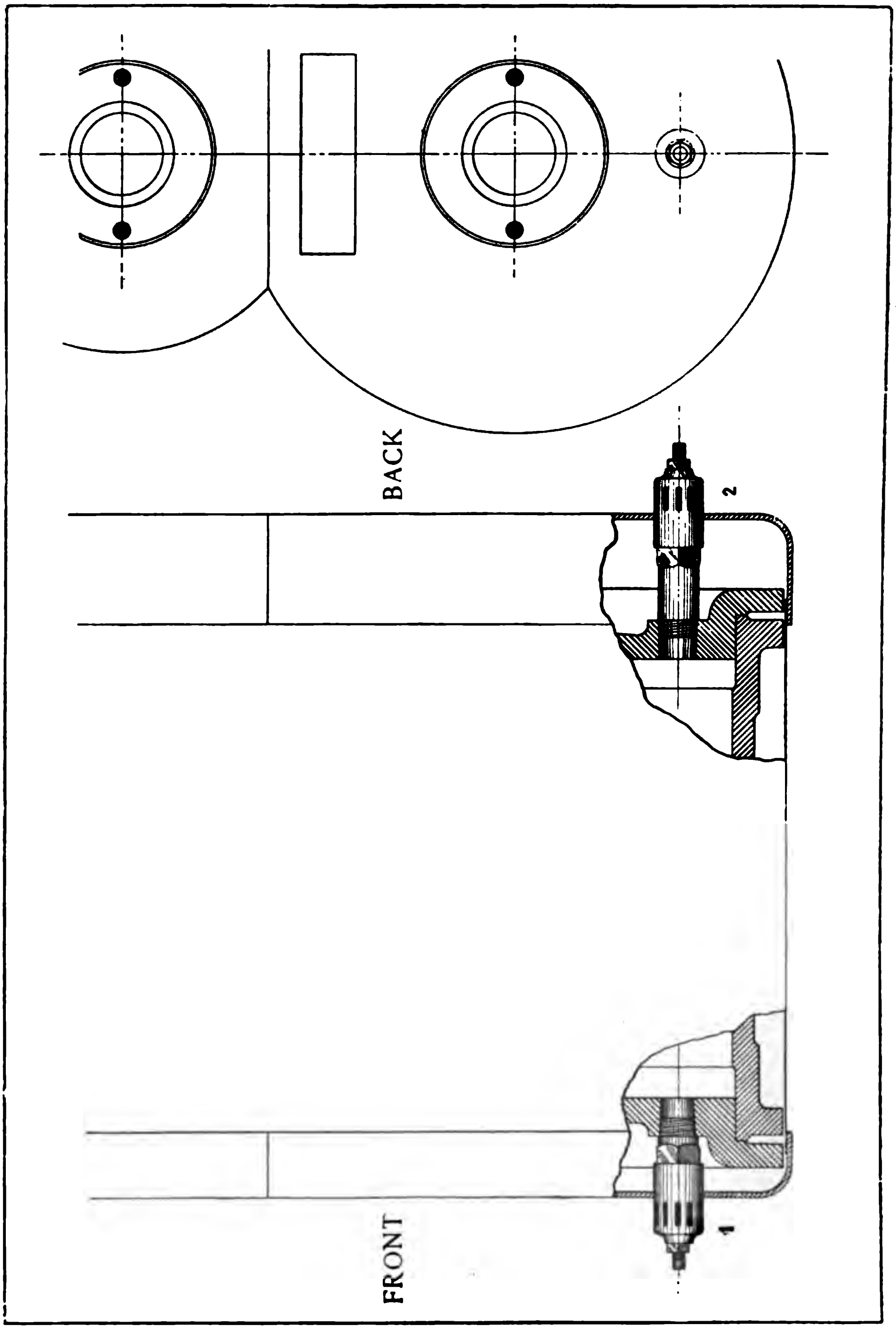


VACUUM VALVE FOR LOW PRESSURE CYLINDER PORTS (VAUCLAIN SYSTEM).

Plate 12. EIFRIGSTEN.

Eigenares . . . 1. Low Pressure Port Vacuum Valve.

Plate 13.



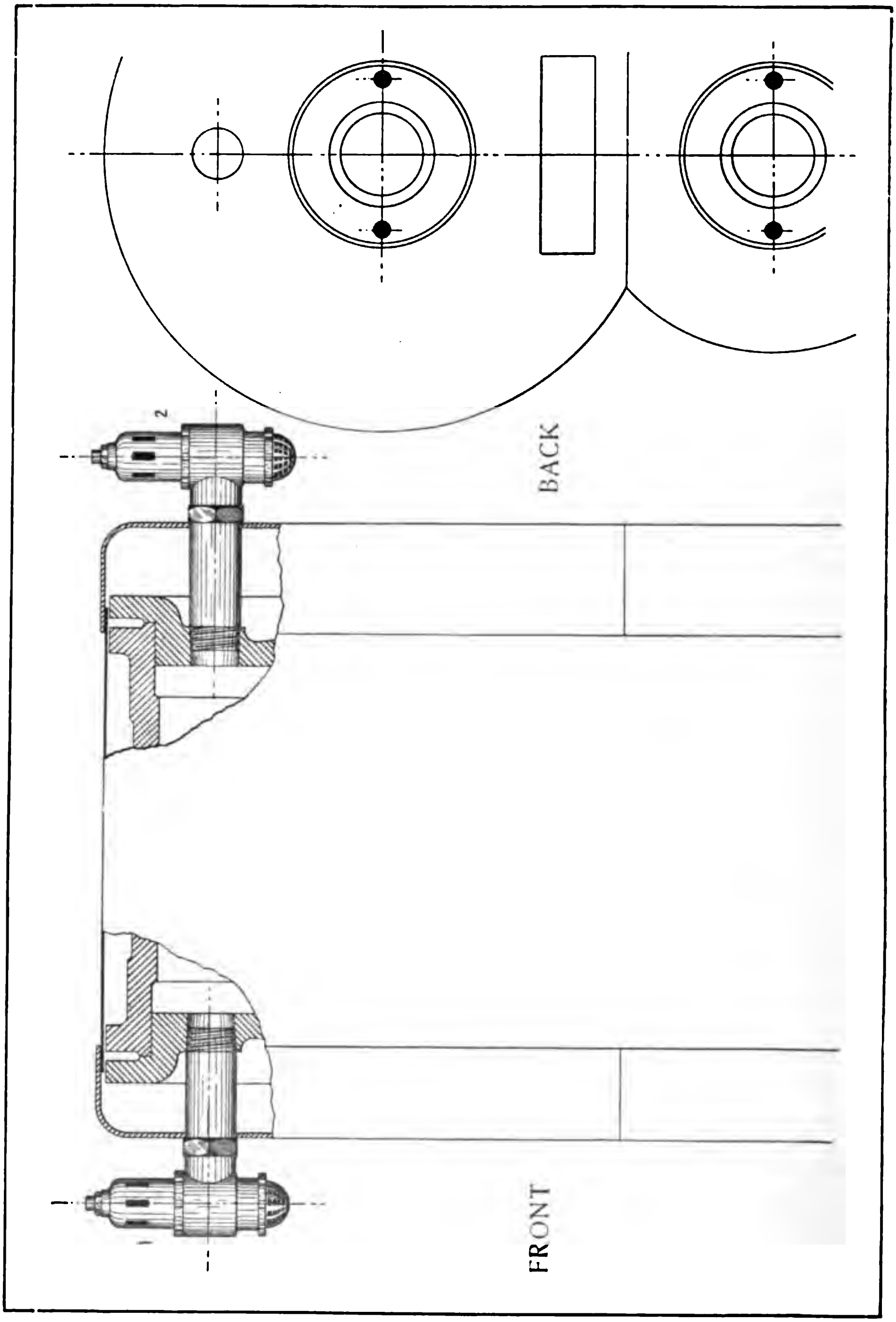
RELIEF VALVE FOR LOW PRESSURE CYLINDER HEADS (VAUCLAIN SYSTEM).

Plate 13. EIGENART.

Eigenartig	1.	Low Pressure Cylinder Head Relief Valve, Front.
Eigenbaat	2.	" " " " " " Back.

In ordering a single valve, state whether it is wanted for front or back cylinder head.

Plate 14.



COMBINED RELIEF AND VACUUM VALVE FOR LOW PRESSURE CYLINDER HEADS (VAUCLAIN SYSTEM).

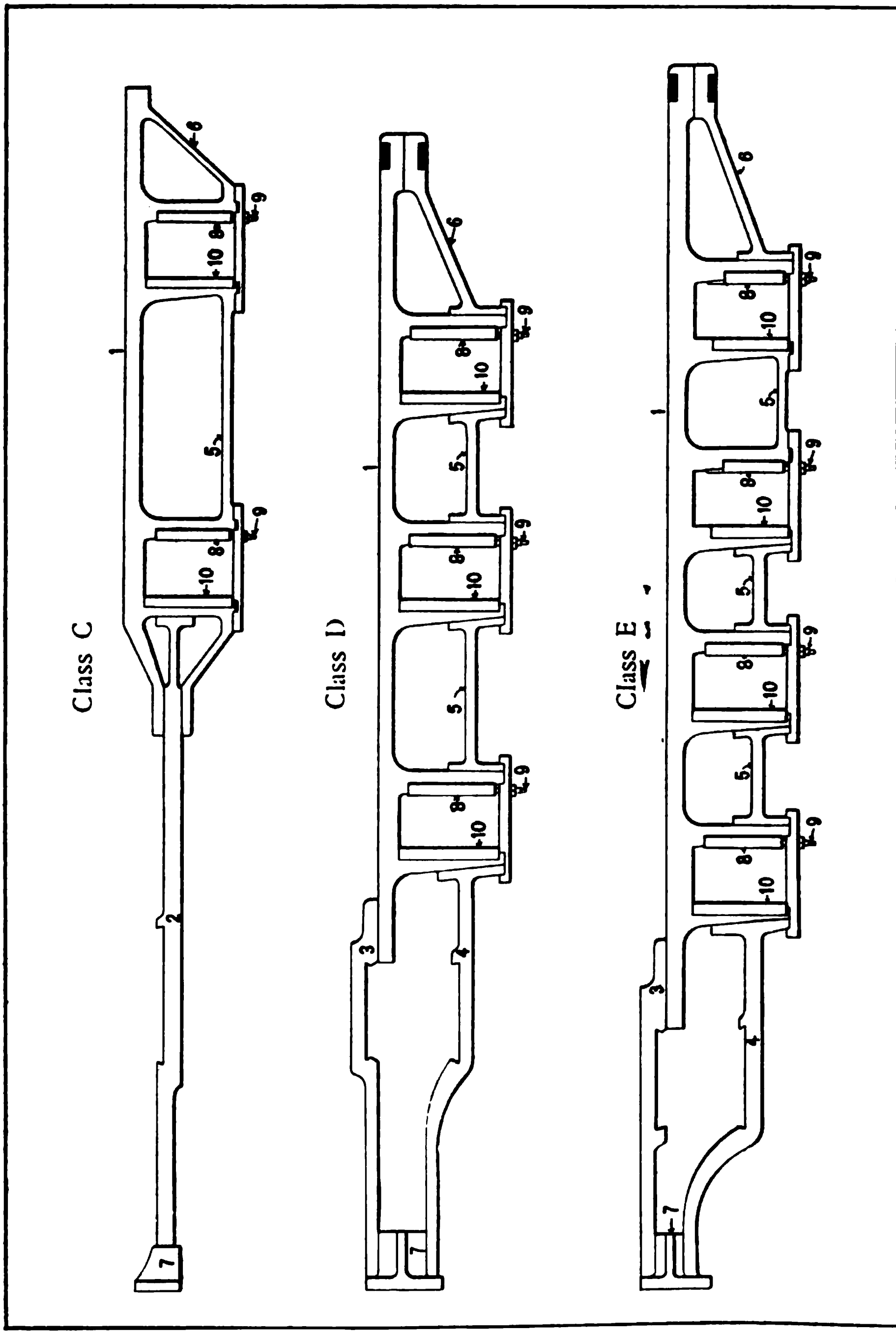
Plate 14. EIGENBATIG.

Eigendom . . . 1. Low Pressure Cylinder Head Relief and Vacuum Valve, Front.

Eigendunk . . . 2. Low Pressure Cylinder Head Relief and Vacuum Valve, Back.

In ordering a single valve, state whether it is wanted for front or back cylinder head.

Plate 15.



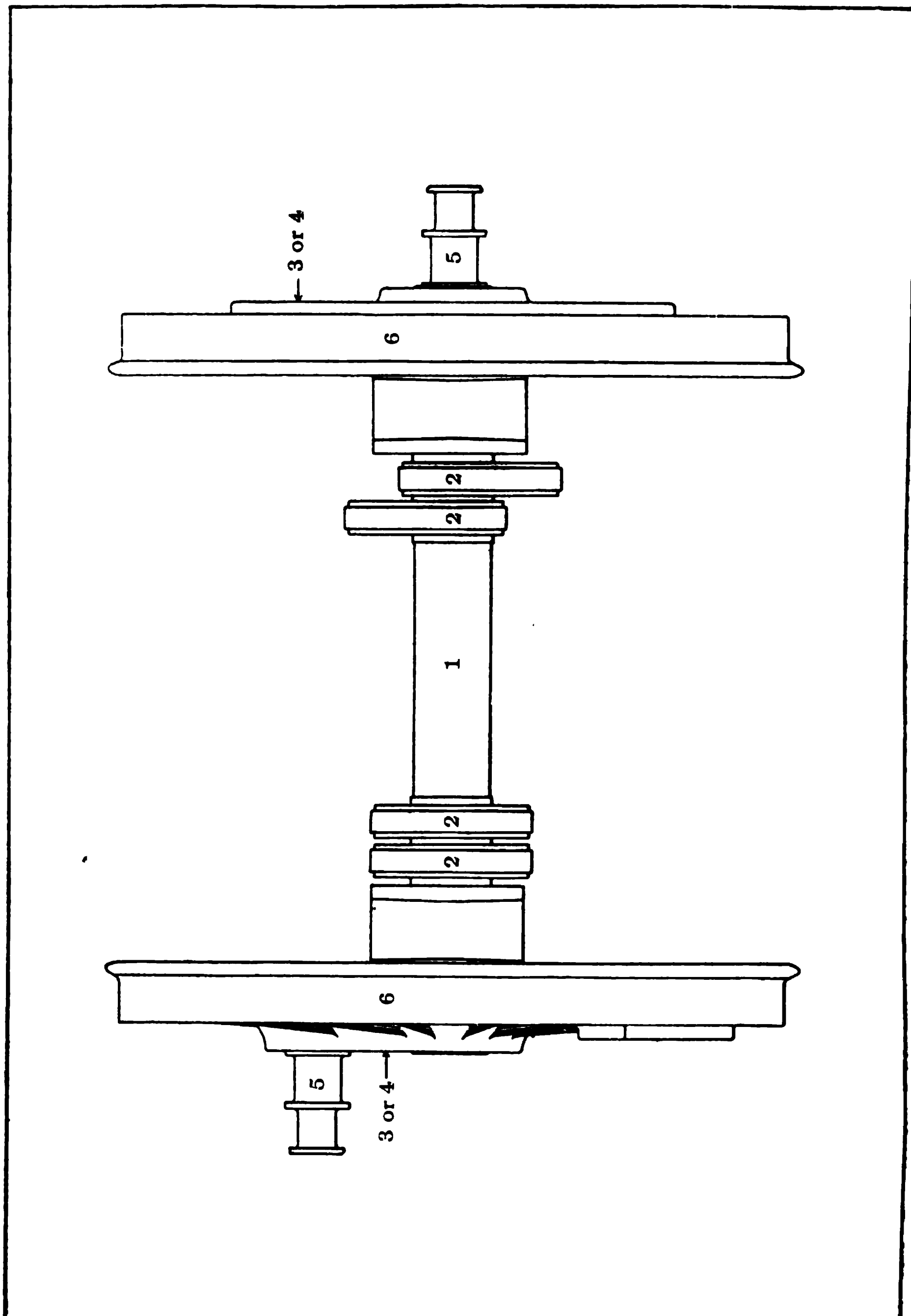
FRAMES AND PEDESTALS.

Plate 15. EIGENEN.

Eigengrund . .	1.	Top Rail and Pedestals.
Eigengut . . .	2.	Front Rail.
Eigenheit . . .	3.	" " Top.
Eigenhilfe . . .	4.	" " Bottom.
Eigening. . . .	5.	Middle Brace.
Eigenleben . .	6.	Back "
Eigenlijk . . .	7.	Frame Filling Piece.
Eigenlob. . . .	8.	Pedestal Wedge.
Eigenmacht . .	9.	" " Bolt.
Eigenname . .	10.	" Gib.

While this plate does not show the pedestal bolted to the frame rail, engines have been constructed on this plan, and when ordering a pedestal to replace, it will only be necessary to refer to its position on the frame.

Plate 16.



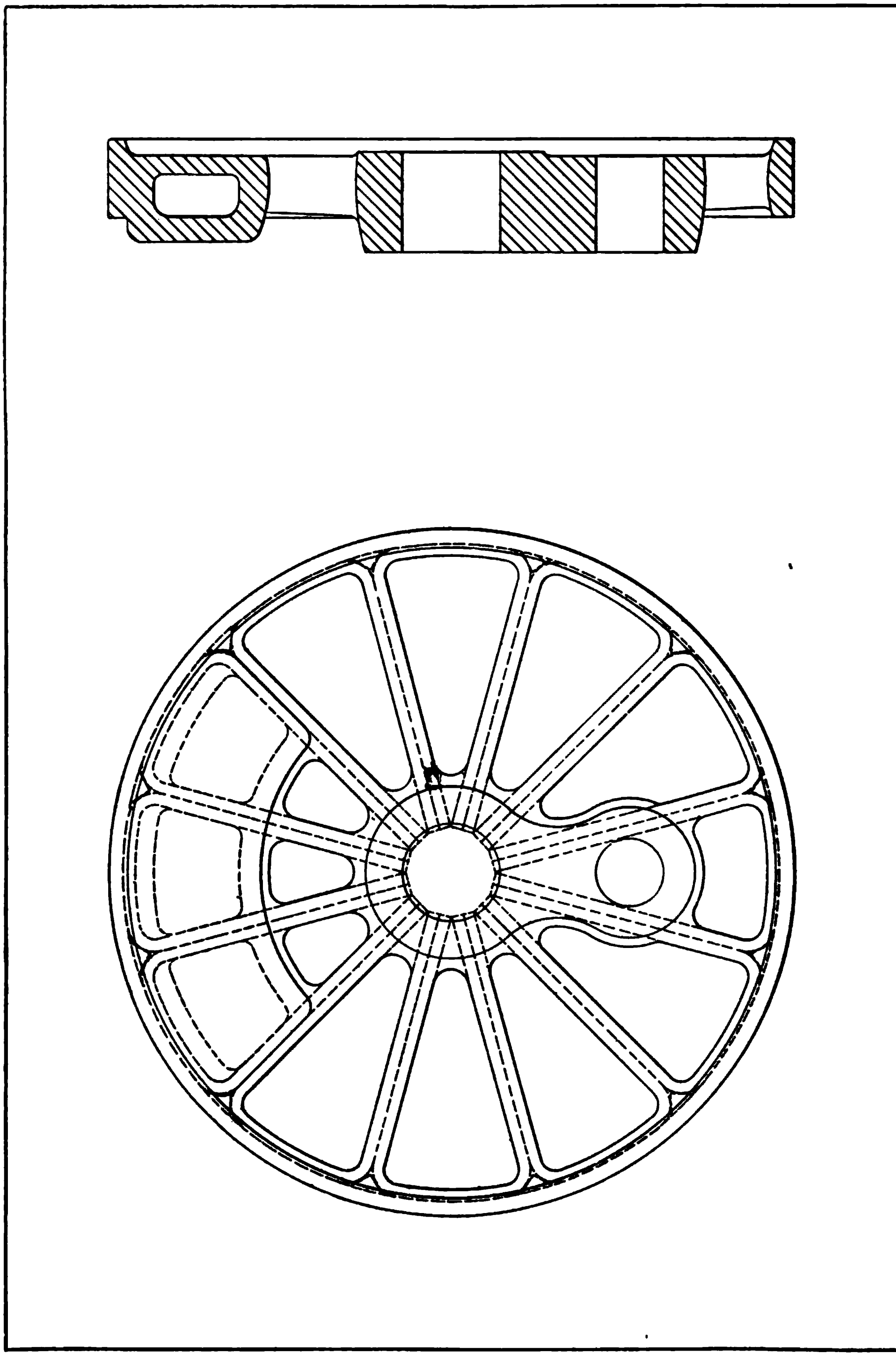
DRIVING WHEELS, AXLE AND TIRES.

Plate 16. EIGENNATUR.

Eigennutz . . .	1.	Axle.
Eigenrache . .	2.	Eccentric.
Eigenruhm . .	3.	Wheel Centre (Cast Iron).
Eigenrupe . . .	4.	" " (Cast Steel).
Eigenschap . .	5.	Wrist Pin.
Eigensinn . . .	6.	Tire.

Orders for wheels or their parts, when not in full sets, should indicate particular pair of wheels required, or that parts are needed for.

Plate 17.



WROUGHT IRON DRIVING WHEEL CENTRE (VAUCLAIN TYPE).

Plate 17. EIGENTLICH.

Eigenwaan . . . Driving Wheel Centre.

For many years cast iron has been used in the United States for driving wheel centres. Lately, however, on account of the increased severity of locomotive service, a demand has arisen for stronger wheels, and this has been met by the wrought iron centre here described.

The method of manufacture is plainly shown by the drawing. The parts are forged separately under drop and steam hammers and a hydraulic machine, and assembled as shown by the dotted lines. They are then brought to a welding heat and placed between steel dies of suitable dimensions, the upper one being connected to the piston rod of a powerful steam hammer. A few blows then weld the parts together, making a homogeneous, solid forging.

These wheels possess great strength, lightness, and beauty of design. The counterbalance is filled with lead when necessary to bring it to the required weight.

For clearer illustration of method of manufacture, see Plate 18, Fig. 1.

Plate 18.

Fig. 1

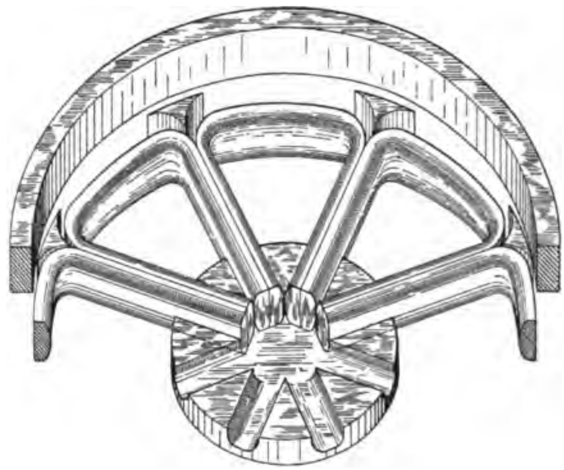
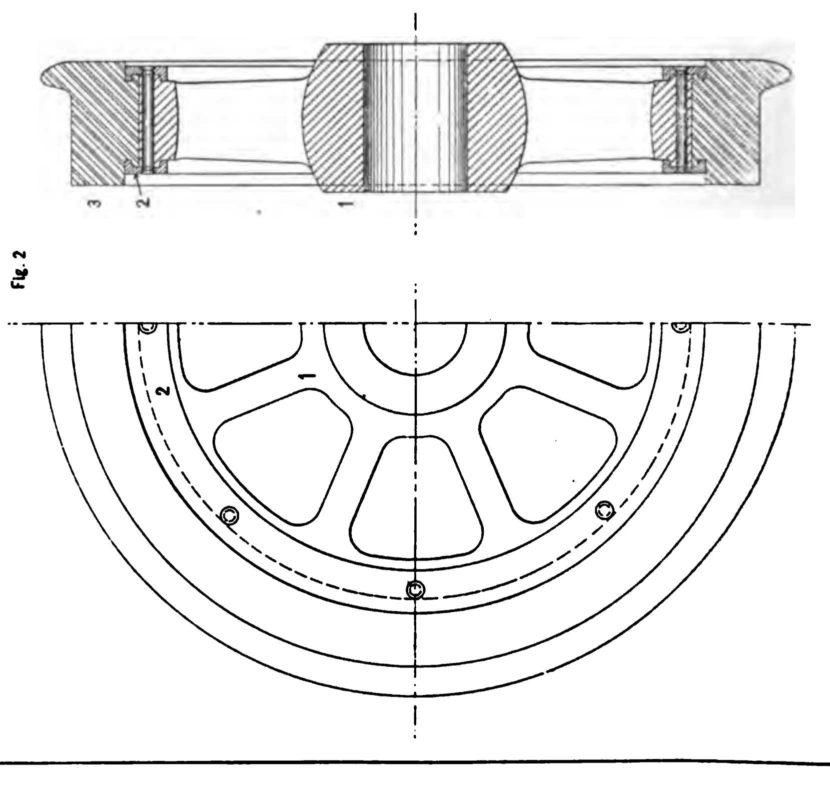


Fig. 2



WROUGHT IRON ENGINE TRUCK AND TENDER WHEEL (VAUCLAIN TYPE).

Plate 18. EIGENWELT.

Eigenwerth . . . 1. Wheel Centre.

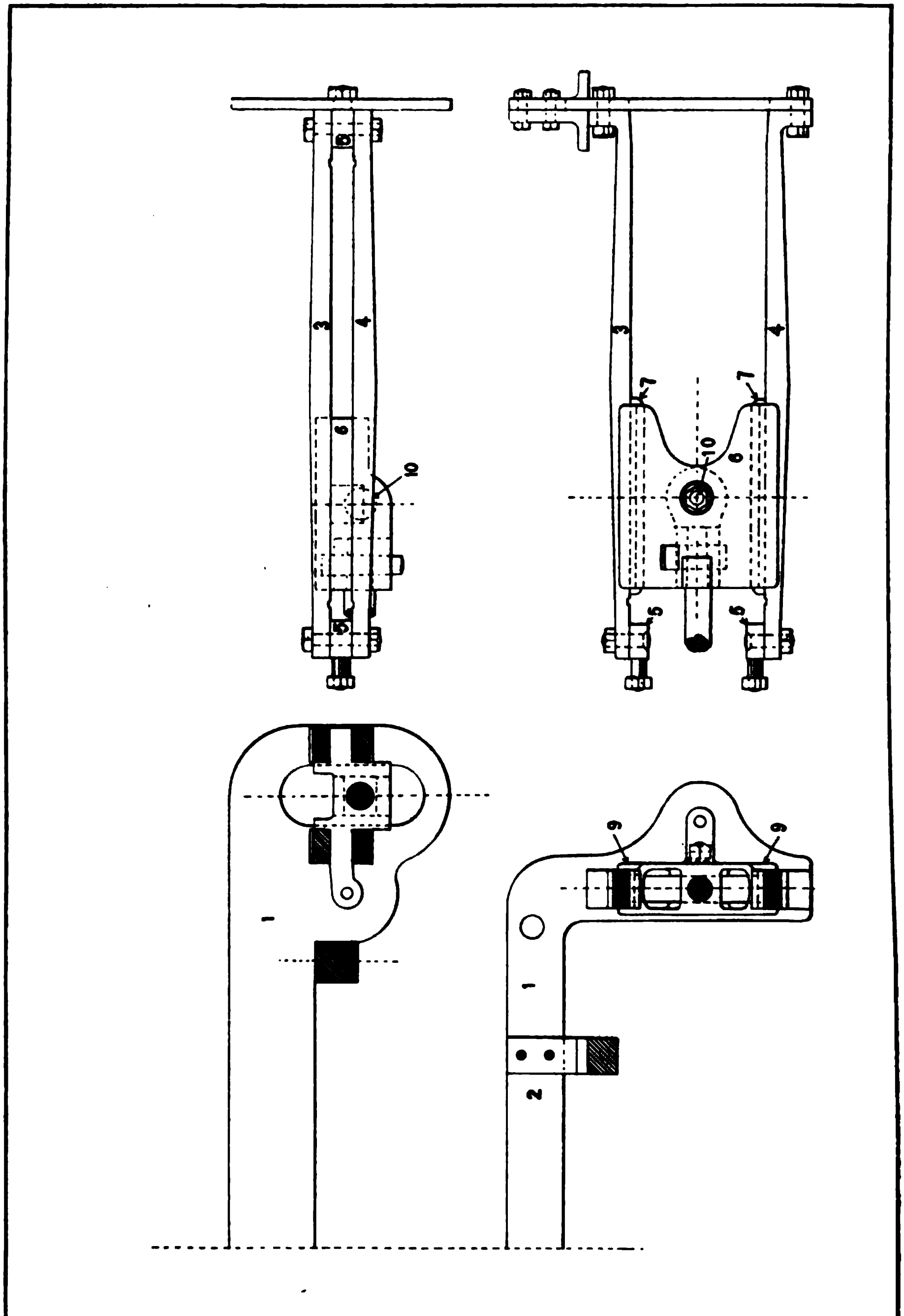
Eigenwijs . . . . 2. Retaining Ring.

Eigenwille . . . . 3. Tire.

The conditions which brought forth the wrought iron driving wheel have caused the existence of the engine truck and tender wheel of the same type. The construction is shown by Fig. 1. The tire is shrunk on the centre and is further secured by two wrought iron retaining rings held by rivets (see Fig. 2). The steel tire lasts much longer than the chilled tread of a cast iron wheel, and when, after having been turned several times, it is finally worn too thin for use, it can be replaced by a new one; whereas, when the tread of a cast iron wheel is worn through the chill, the whole wheel must be thrown away.

For the position of these wheels in the locomotive, see Plates 34 and 64.

Plate 19.



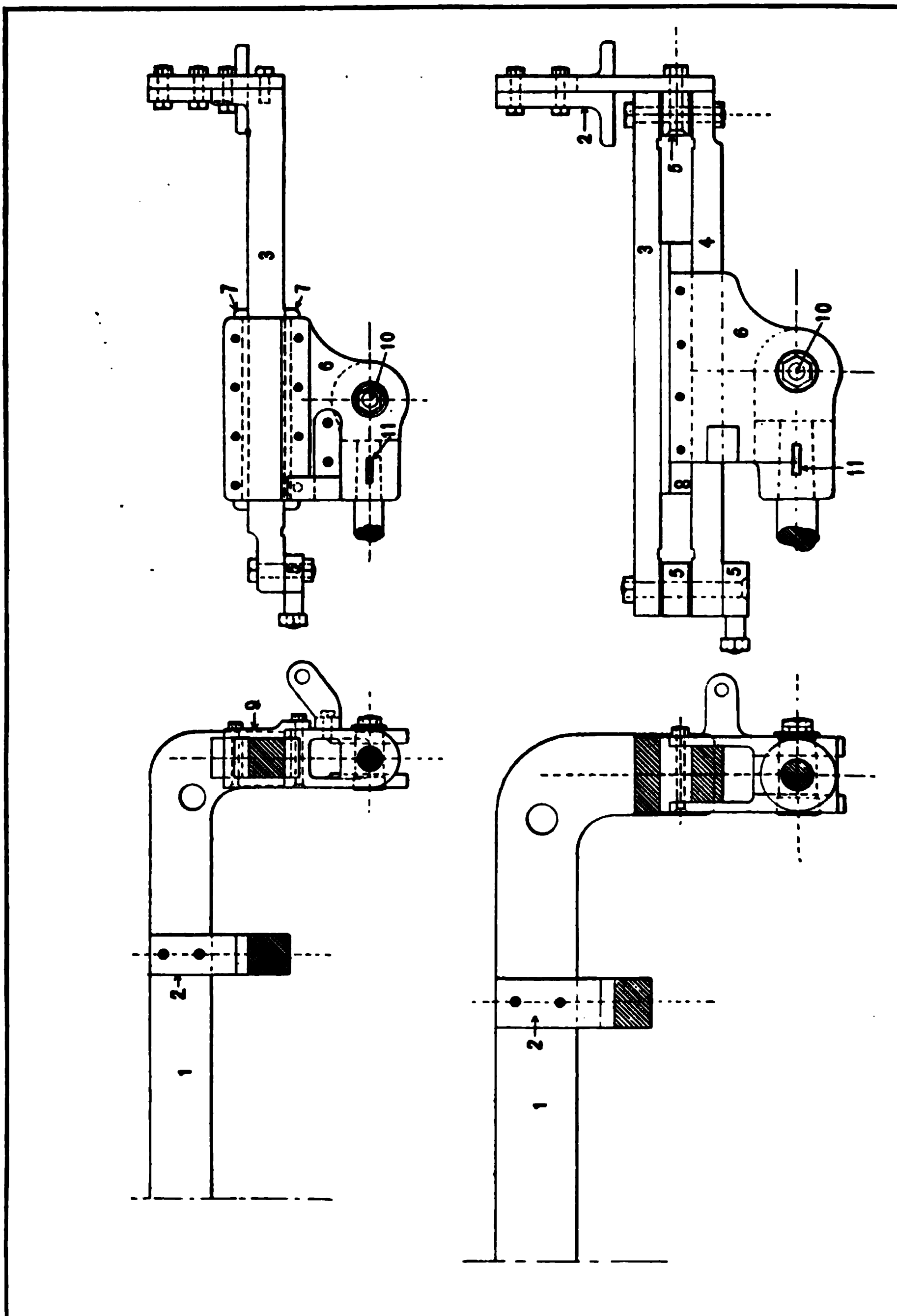
GUIDE BEARER, GUIDES AND CROSSHEAD FOR SINGLE EXPANSION LOCOMOTIVES.

Plate 19. EIGHTEENMO.

Eighteenth . . .	1.	Guide Bearer.	
Eightfold	2.	" "	Knee.
Eighthly	3.	Top Guide Bar.	
Eightscore . . .	4.	Bottom Guide Bar.	
Eigilbert	5.	Guide Fillings.	
Eigilwich	6.	Crosshead.	
Eihaut	7.	"	Gibs.
Eikeboom	9.	"	Plate
Eikeboomen . .	10.	"	Pin.
Eikekrans	11.	"	Key.

Orders for guides, when not in full sets, should specify whether top or bottom guides are wanted, and for crosshead the side should be given.

Plate 20.



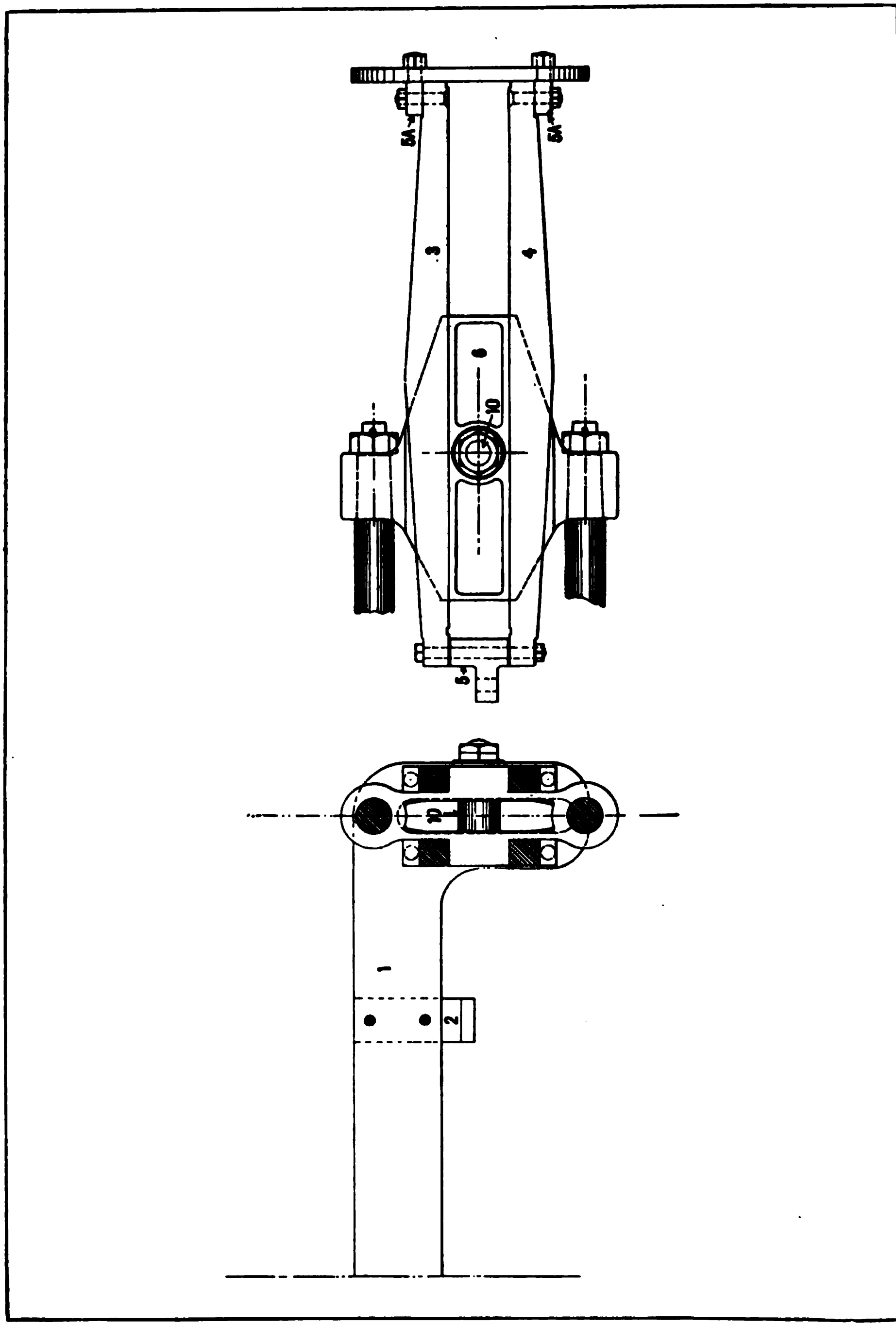
GUIDE BEARER, GUIDES AND CROSSHEAD FOR SINGLE EXPANSION LOCOMOTIVES.

Plate 20. EIGHTEENMO.

Eighteenth . . .	1.	Guide Bearer.	
Eightfold	2.	" "	Knee.
Eighthly	3.	Top Guide Bar.	
Eightscore . . .	4.	Bottom Guide Bar.	
Eigilbert	5.	Guide Fillings.	
Eigilwich	6.	Crosshead.	
Eihaut	7.	"	Gibs.
Eikeblad	8.	"	Filling Piece.
Eikeboom	9.	"	Plate.
Eikeboomen . .	10.	"	Pin.
Eikekrans	11.	"	Key.

Orders for guides, when not in full sets, should specify whether top or bottom guides are wanted, and for crosshead the side should be given.

Plate 21.



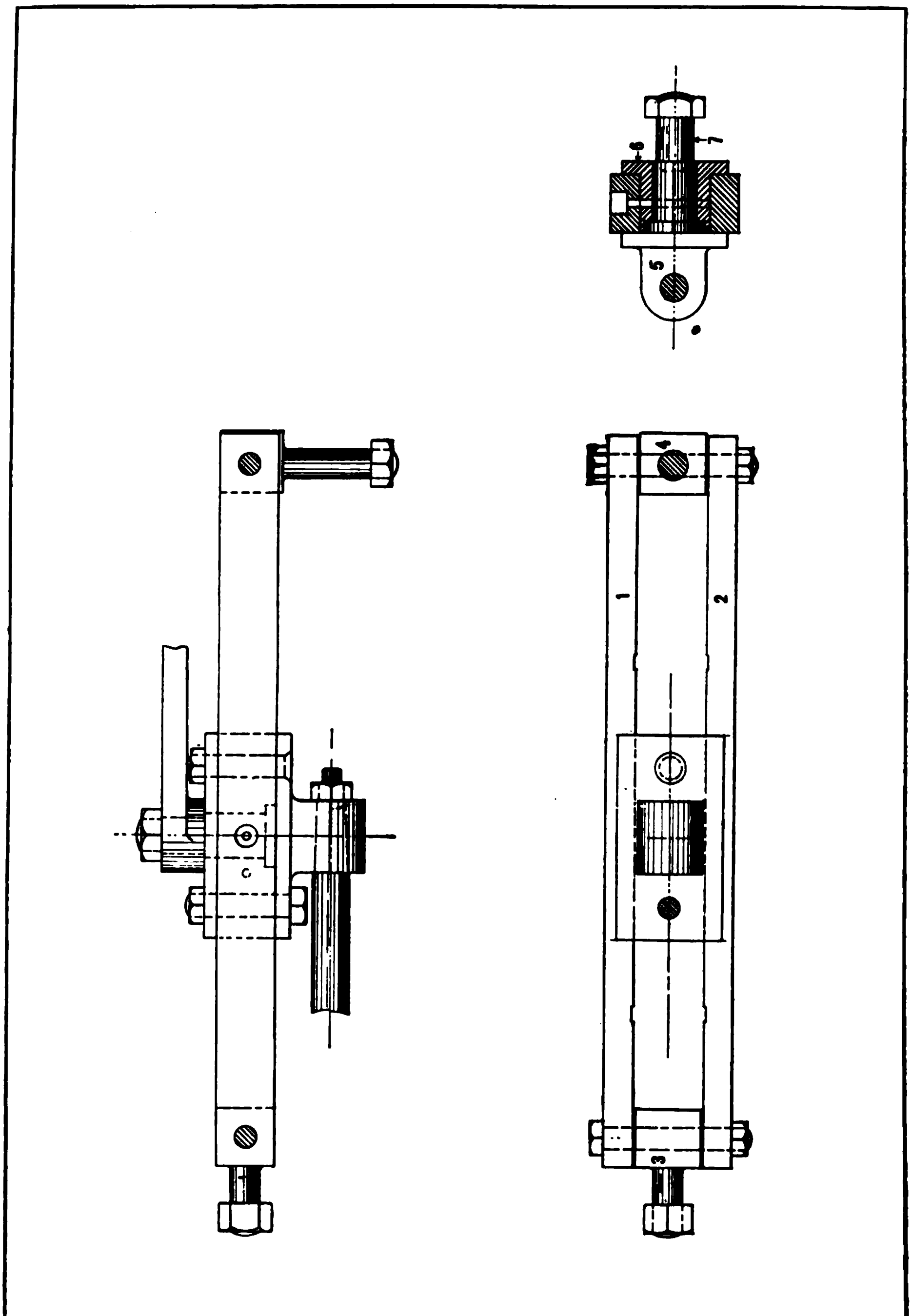
GUIDE BEARER, GUIDES AND CROSSHEAD FOR BALDWIN COMPOUND LOCOMOTIVES (VAUCLAIN SYSTEM).

Plate 21. EIKEKROON.

Eikelaars . . .	1.	Guide Bearer.
Eikeldop	2.	" " Knee.
Eikelmuis . . .	3.	Top Guide Bar.
Eikeloof	4.	Bottom Guide Bar.
Eikeloogst . . .	5.	Guide Front Filling or Block.
Eikels	5A.	" Back " " "
Eikelsteen . . .	6.	Crosshead.
Eikeltijd	10.	" Pin.

Orders for guides, when not in full sets, should specify whether top or bottom guides are wanted, and for crosshead the side should be given.

Plate 22.



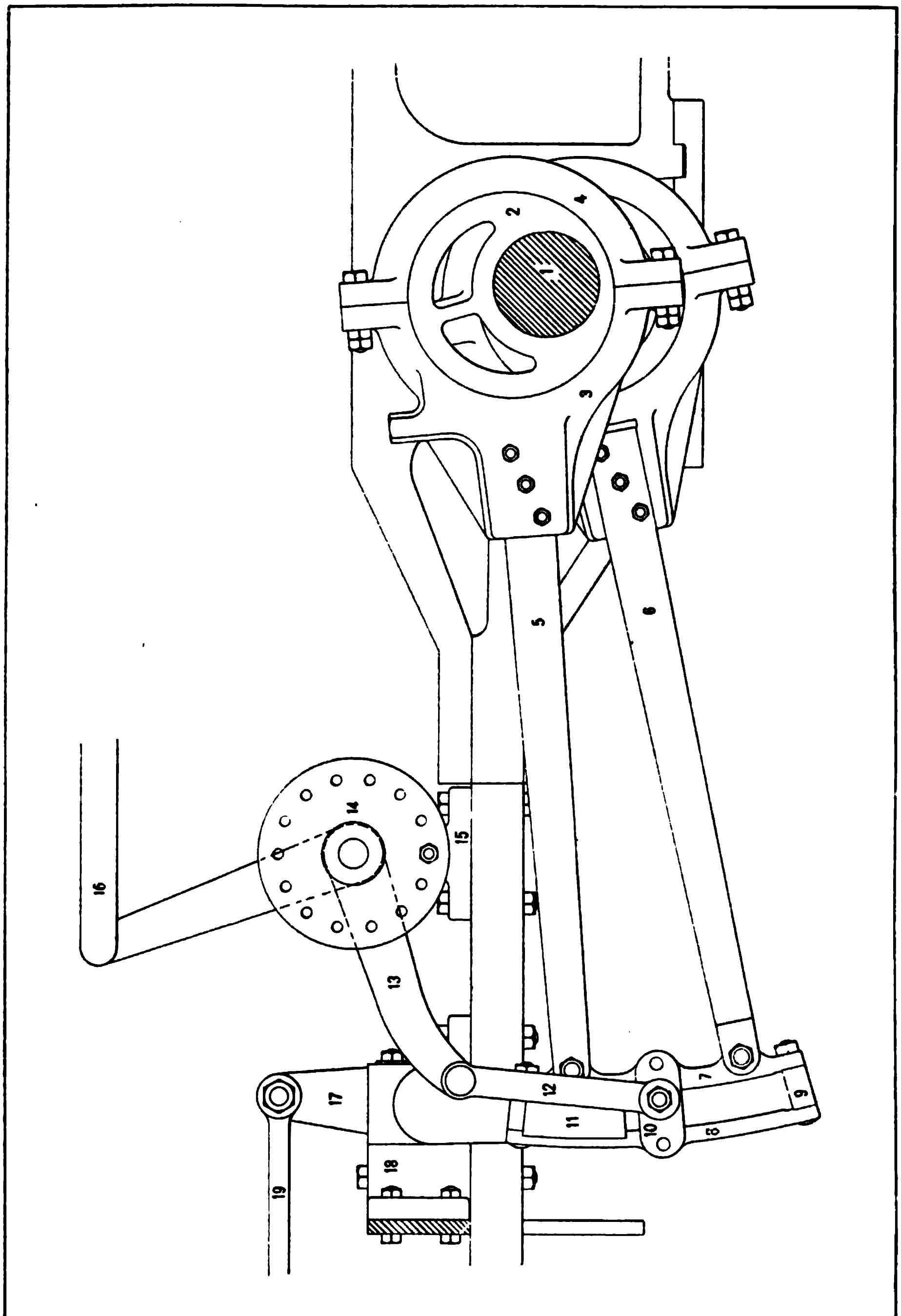
VALVE STEM GUIDES AND CROSSHEAD FOR BALDWIN COMPOUND LOCOMOTIVES (VAUCLAIN SYSTEM).

Plate 22. EIKELTJES.

Eikenappel . .	1.	Valve Stem Top Guide Bar.
Eikenbast . .	2.	" " Bottom Guide Bar.
Eikenbosch .	3.	" " Guide Front Filling or Block.
Eikenhout . .	4.	" " " Back " " "
Eikenlaan . .	5.	" " Crosshead Lug.
Eikenmos . .	6.	" " Crosshead.
Eikenplant .	7.	" " " Pin.

Orders for valve stem guides, when not in full sets, should specify whether top or bottom guides are wanted; and for crosshead the side should be given.

Plate 23.



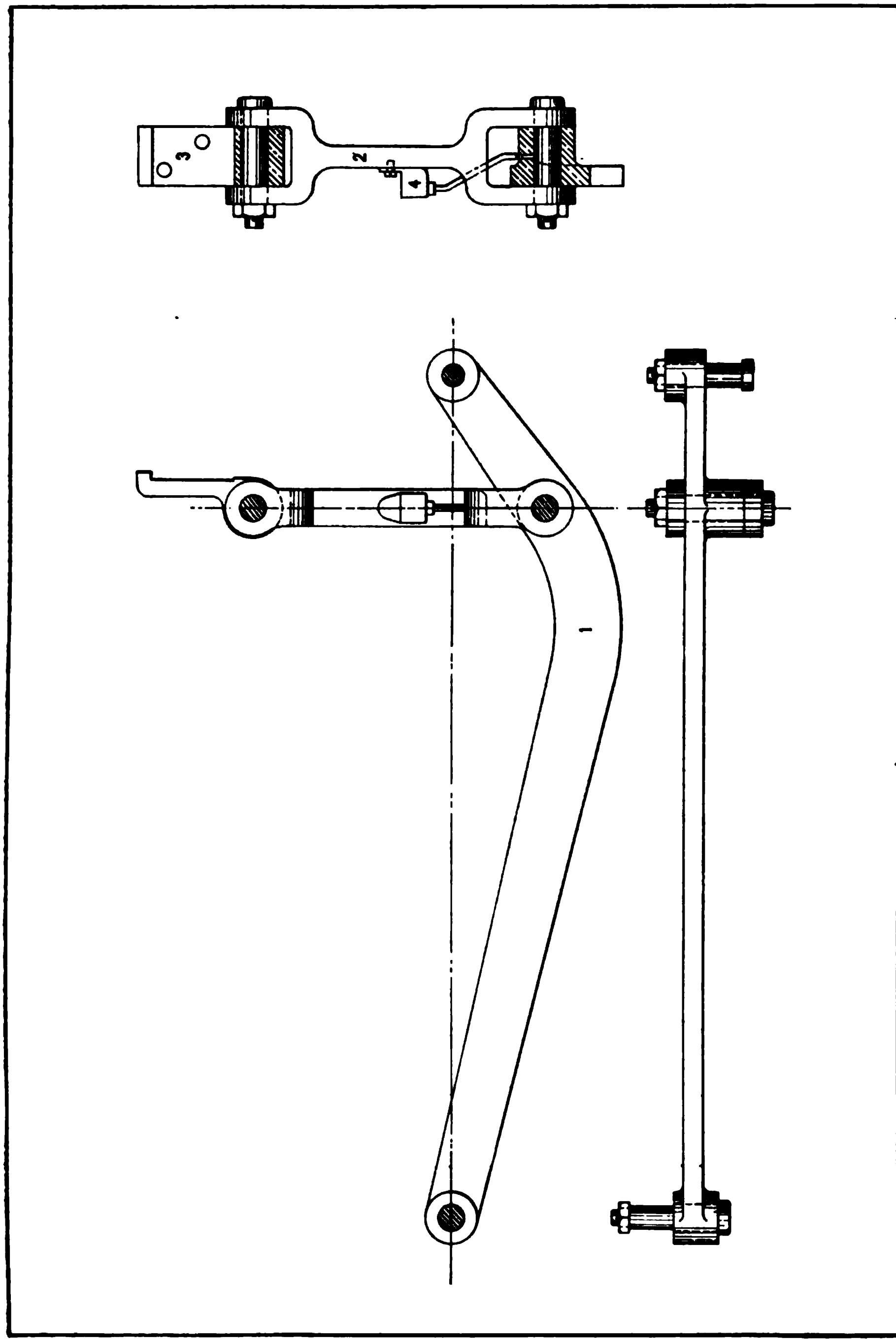
VALVE MOTION WORK.

Plate 23. EIKENVAREN.

Eikenwoud .	1.	Axle.
Eikon	2.	Eccentrics.
Eilamides .	3.	Eccentric Strap, Front Half.
	4.	" " Back "
Eiland	5.	" Rod, Inside (Forward Motion).
Eilandjes. . .	6.	" " Outside (Back ").
Eilbote	7.	Reverse Link, Back Half.
Eileithyia . .	8.	" " Front "
Eilfertig . . .	9.	" " Filling Piece.
Eilmarsch . .	10.	" " Saddle.
Eiloof	11.	Sliding Block.
Eilpost	12.	Link Lifter.
Eilritt	13.	Reverse Shaft.
Eilwagen . .	14.	Counterbalance Spring.
Eilzug	15.	Reverse Shaft Bearing.
Eimer	16.	" Lever Rod.
Eimerbank. .	17.	Rock Shaft.
Eimerkette .	18.	" " Box.
Eimermasse .	19.	Valve Rod.

Orders for reverse shaft bearings, rock shaft boxes, and link work, when not in sets, should specify the side required for.

Plate 24.



ROCKSHAFT ROD AND HANGER FOR BALDWIN COMPOUND LOCOMOTIVES (VAUCLAIN SYSTEM).

Plate 24. EIMERWEISE.

Einachsig . . .	1.	Rockshaft Rod.			
Einackern . . .	2.	"	"	Hanger.	
Einaetzen . . .	3.	"	"	"	Bearing.
Einaeugig . . .	4.	"	"	Oil Cup.	

Orders for rockshaft rods, hangers and bearings, when not in sets, should specify the side required for.

Plate 25.

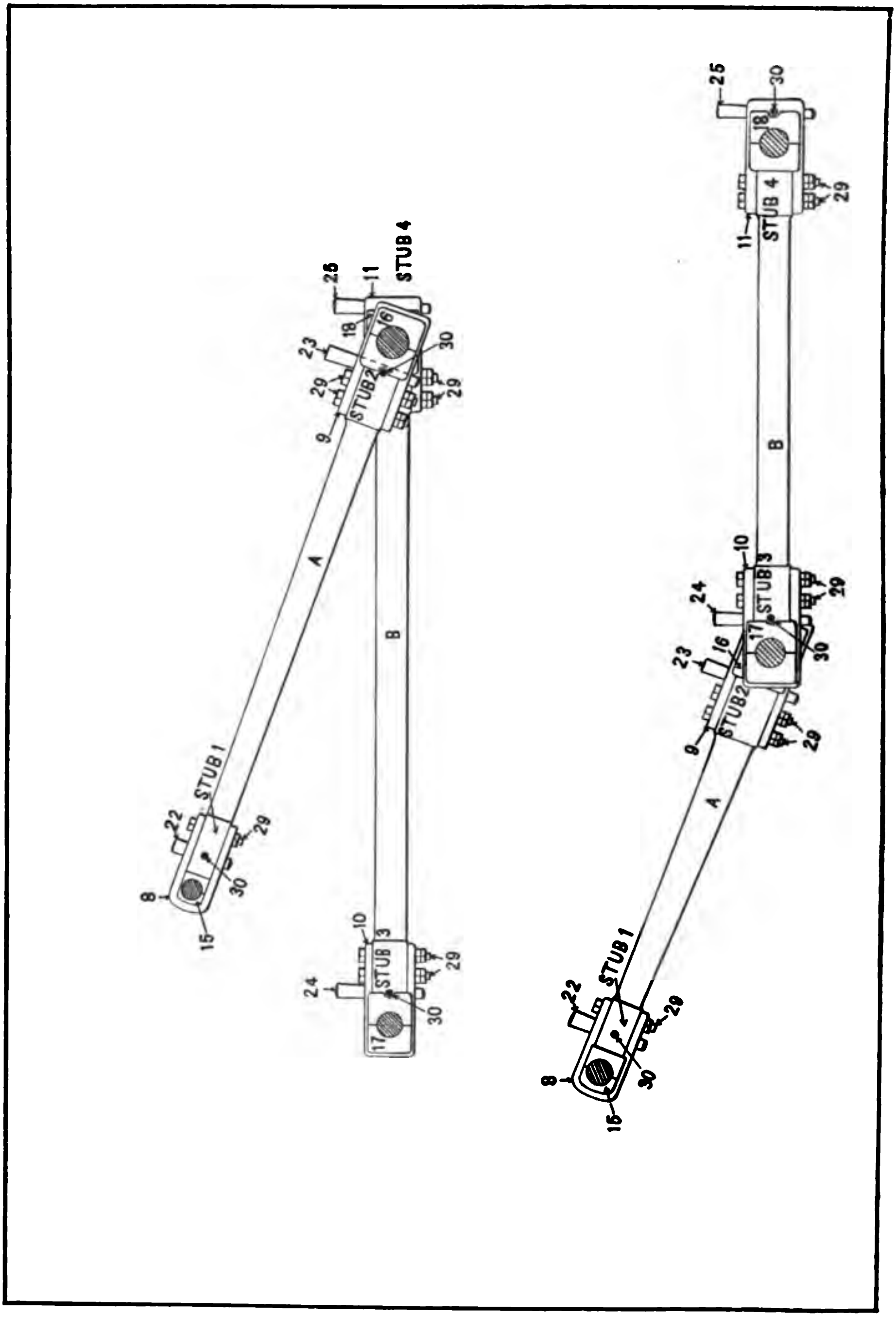
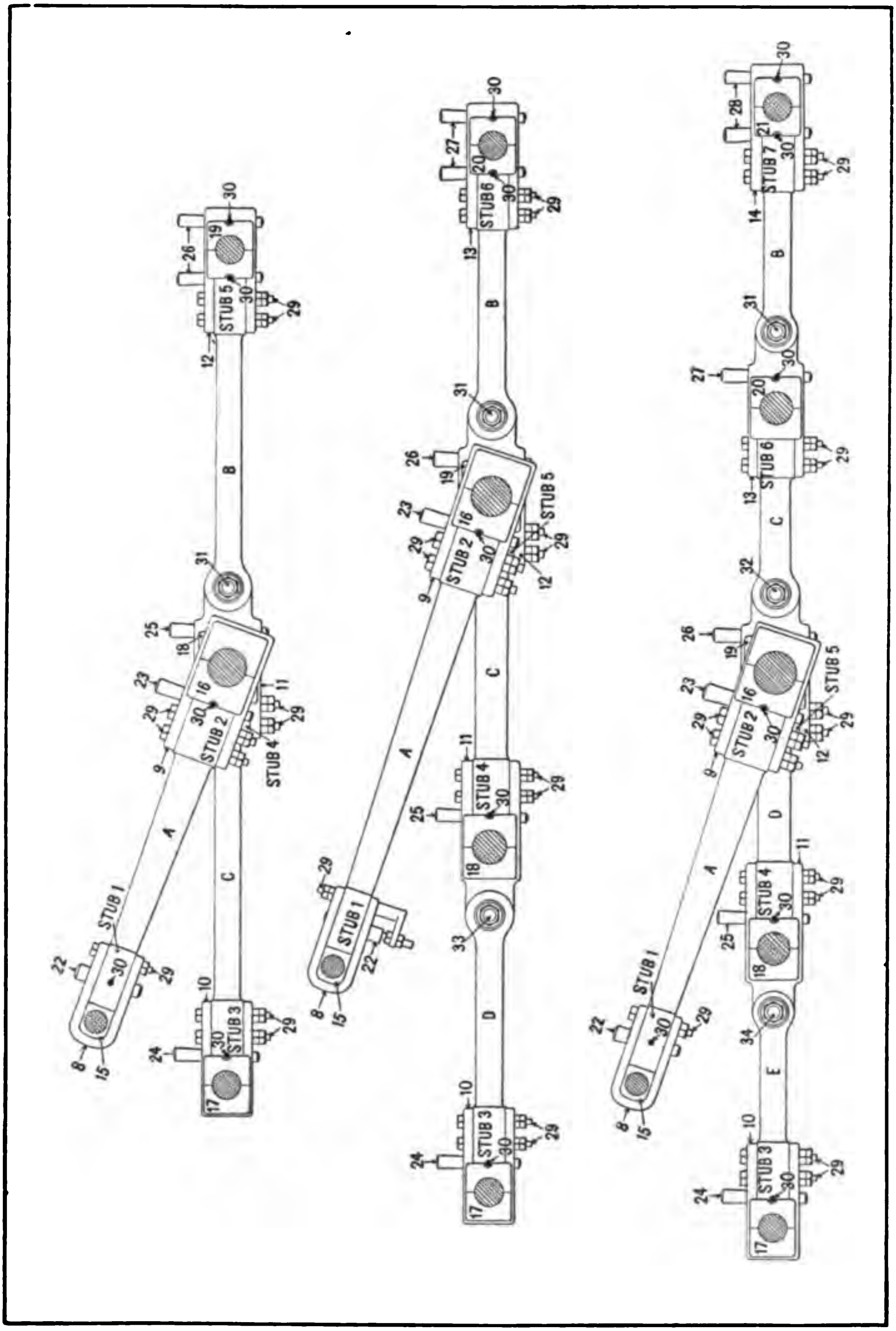


Plate 26.



RODS, STRAPS AND BRASSES.

Plates 25 and 26. EINANDER.

Einarmig . . .	A.	Main Rod.
Einathmen . .	B.	Back Parallel or Side Rod.
Einballen . . .	C.	Second " " " "
Einband	D.	Third " " " "
Einbandeln . .	E.	Fourth " " " "

Einbein	8.	Strap of Stub 1.
Einbeinig . .	9.	" " " 2.
Einbetteln . .	10.	" " " 3.
Einbildsam . .	11.	" " " 4.
Einbildung . .	12.	" " " 5.
Einbinden . .	13.	" " " 6.
Einbisamen .	14.	" " " 7.
Einblatt . . .	15.	Brass " " 1.
Einblick . . .	16.	" " " 2.
Einddoel . . .	17.	" " " 3.
Eindelijk . . .	18.	" " " 4.
Eindeloos . .	19.	" " " 5.

Eindigheid . .	20.	Brass of Stub 6.
Eindiging . .	21.	" " " 7.
Eindklank . .	22.	Key " " 1.
Eindletter . .	23.	" " " 2.
Eindorren . .	24.	" " " 3.
Eindpaal . . .	25.	" " " 4.
Eindrijm . . .	26.	" " " 5.
Eindruck . . .	27.	" " " 6.
Eindteeken . .	28.	" " " 7.
Eindvonnis . .	29.	Bolt.
Einerhand . .	30.	Set Screw.
Einfaedeln . .	31.	Jaw Pin for Rod B.
Einfesseln . .	32.	" " " " C.
Einfilzen . . .	33.	" " " " D.
Einflecken . .	34.	" " " " E.

When rods are not ordered in full sets, the side for which the parts are wanted should be given, as well as the letter of the rod and the stub number.

Give the stub number in all cases when ordering straps, brasses, keys, bolts, or set screws.

Plate 27.

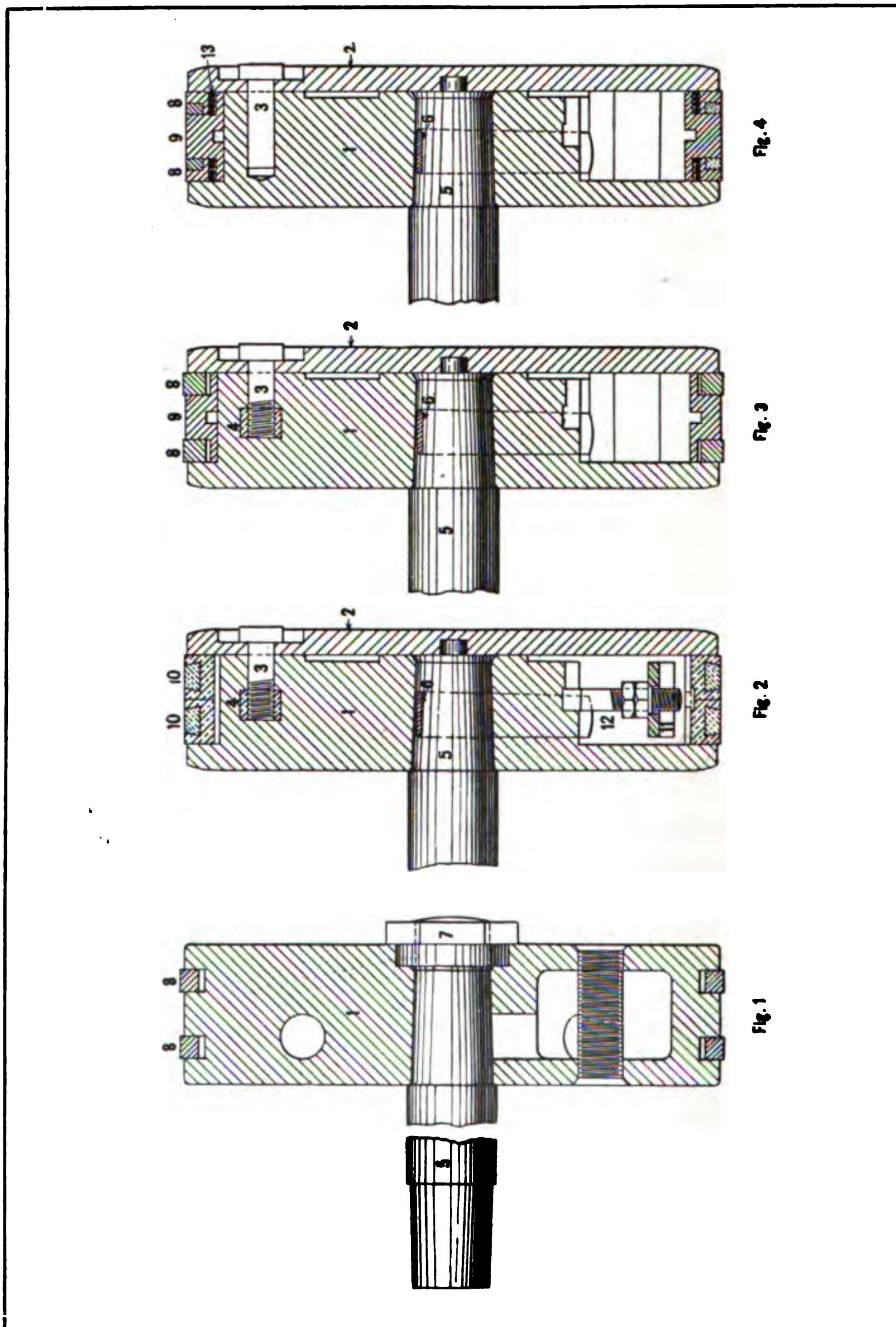


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Fig. 4
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Fig. 3
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12
11
Fig. 2
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8
1
5
Fig. 1

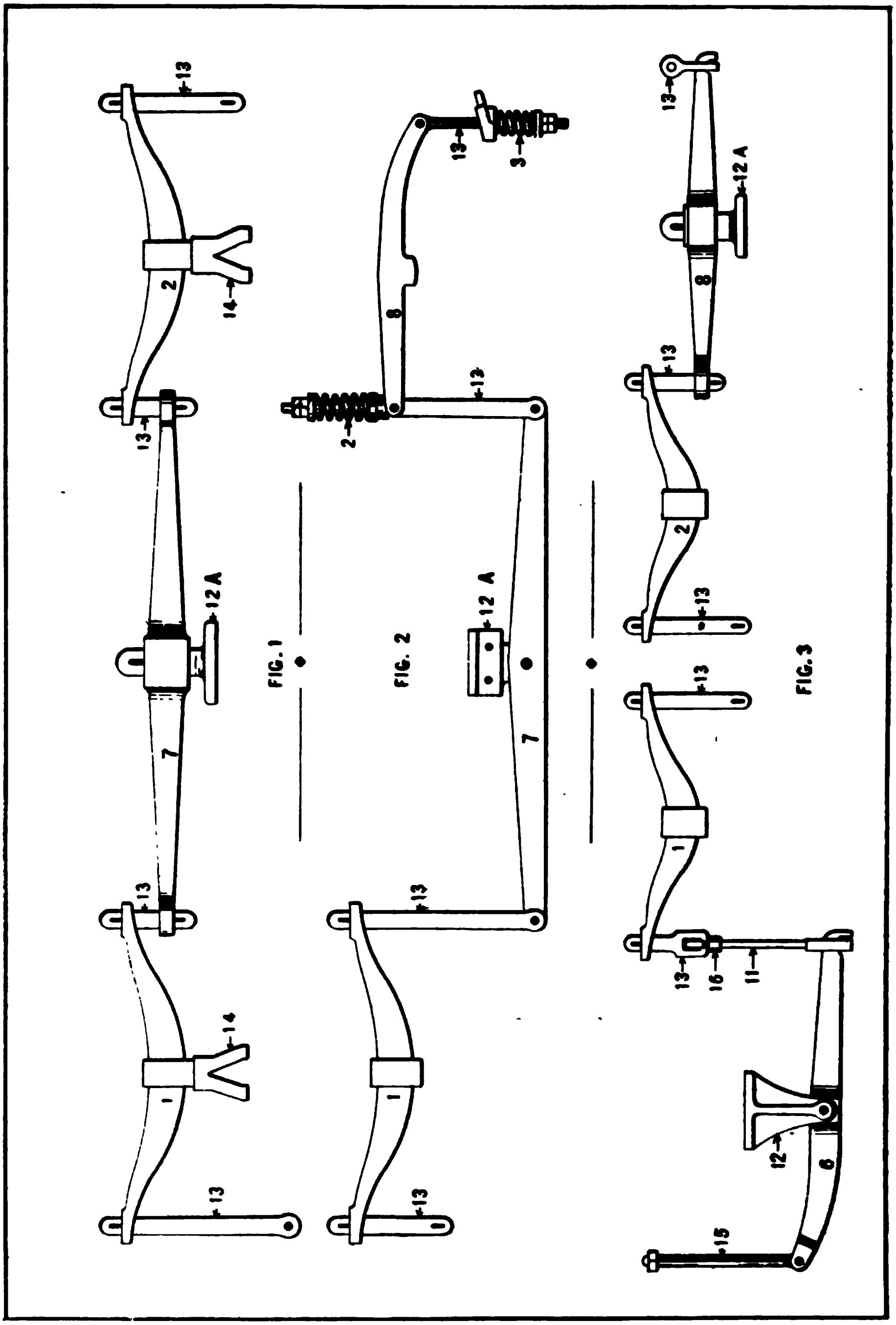
PISTONS AND PACKING RINGS.

Plate 27. EINFLUG.

Einfluss . . .	1.	Piston Head.
Einfoermig .	2.	" Follower.
Einfordern .	3.	" " Bolts.
Einformen. .	4.	" " Bolt Nuts.
Einfrage . . .	5.	" Rod.
Einfrieden. .	6.	" " Key.
Einfuhr . . .	7.	" " Nut.
Einfurchen .	8.	" Spring Rings (Cast Iron).
Eingabe . . .	9.	" T Ring (Cast Iron).
Eingaengig .	10.	" Brass and Composition Rings.
Eingaukeln .	11.	" Spring.
Eingehaust .	12.	" " Studs and Nuts.
Eingehend .	13.	" Wire Springs.

This plate indicates four kinds of packing generally used, and customers can readily refer to the particular pieces by the number of the piece, as well as the figure number.

Plate 28.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14
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12 A
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13
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1
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13
3
8
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13
12 A
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13
13
FIG. 1
FIG. 2
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12 A
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15
FIG. 3

Plate 29.

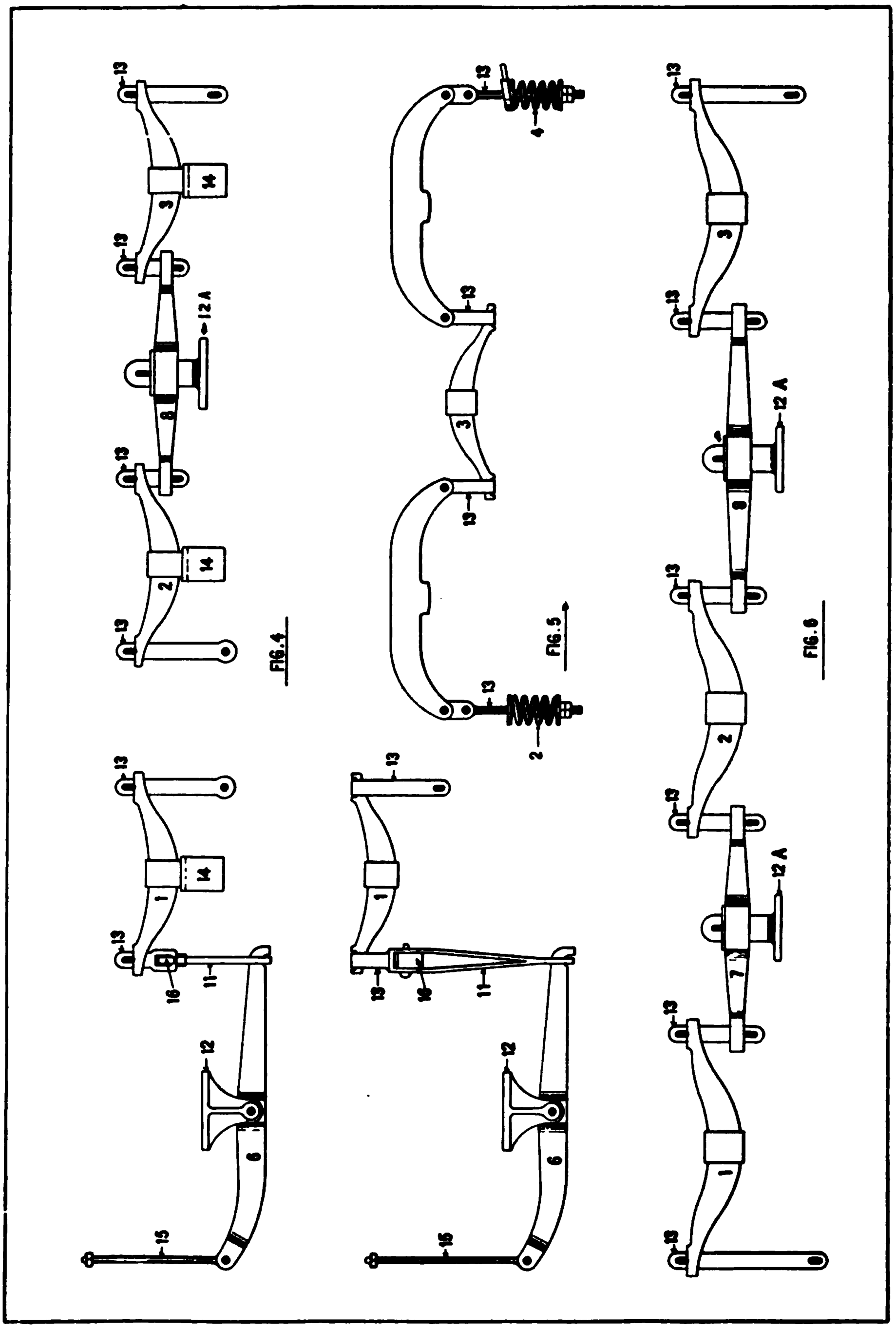


Plate 30.

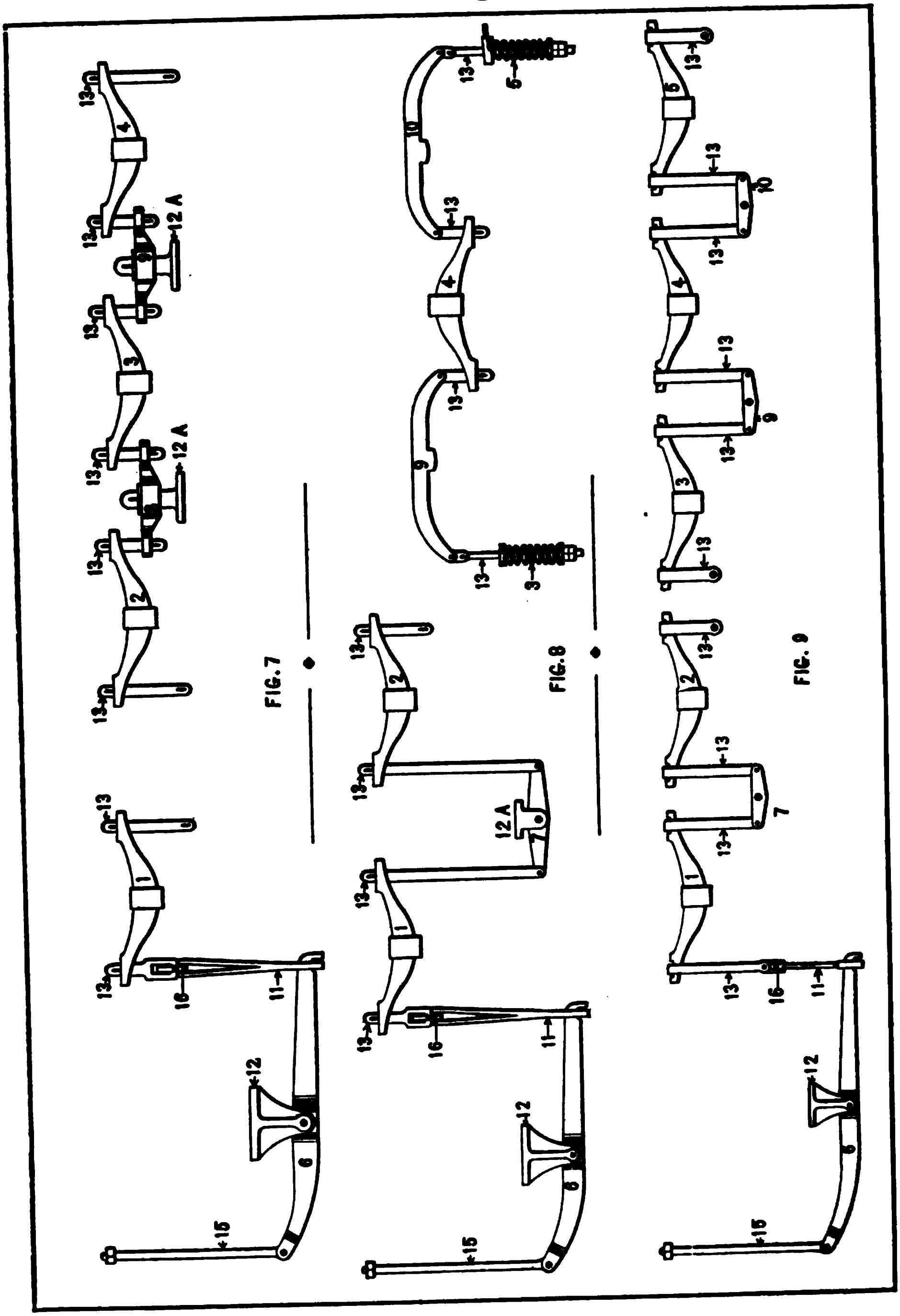


FIG. 7

FIG. 8

FIG. 9

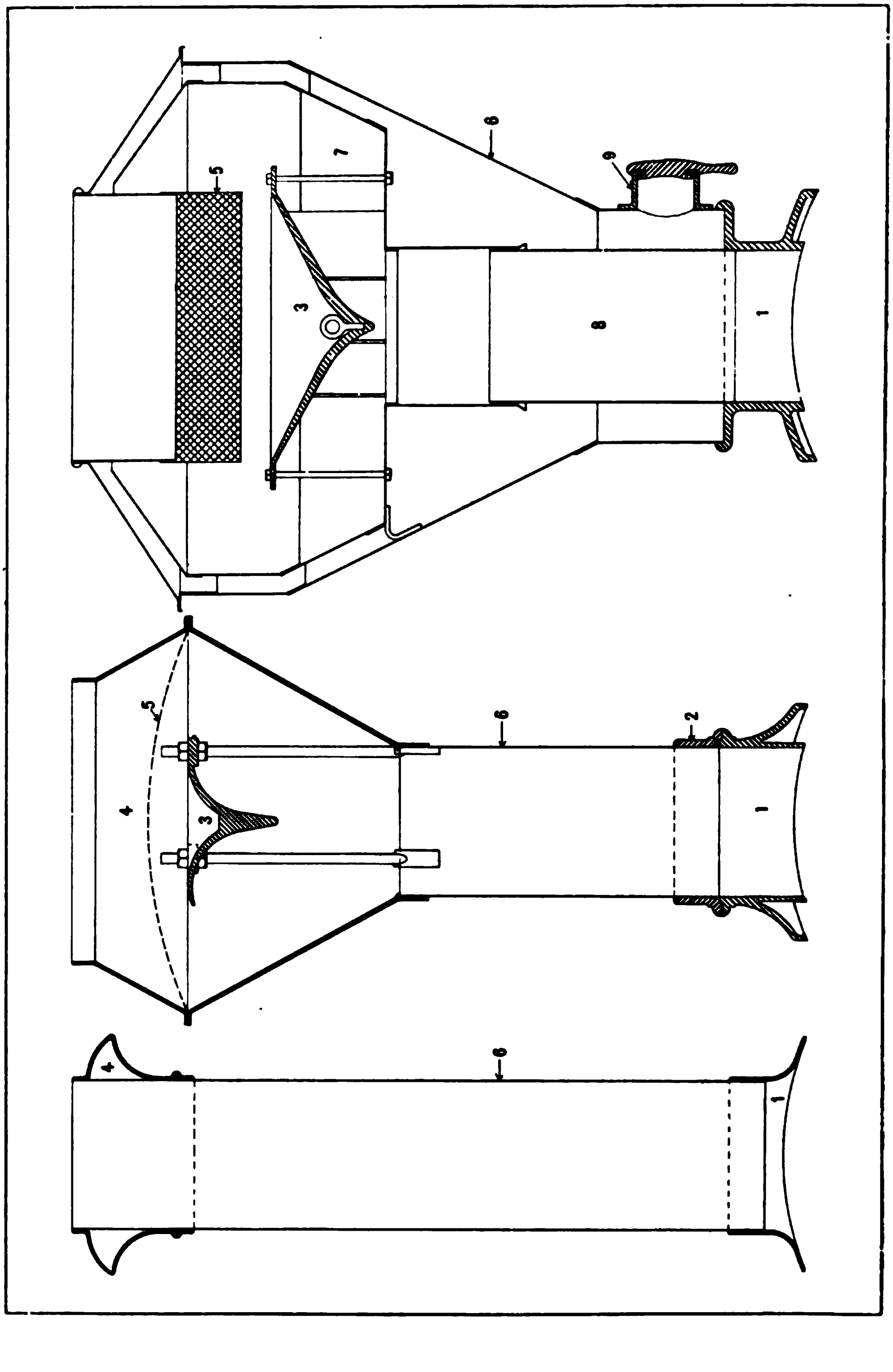
SPRINGS AND EQUALIZING WORK.

Plates 28, 29 and 30. EINGEHOLT.

Eingeimpft . .	1.	Forward Driving Spring.
Eingejagt . . .	2.	Second " "
Eingekauft . .	3.	Third " "
Eingekehrt . .	4.	Fourth " "
Eingekerbt . .	5.	Fifth " "
Eingekramt . .	6.	Forward Truck Equalizing Beam.
Eingelangt . .	7.	Driving Equalizing Beam, First.
Eingelegt . . .	8.	" " " Second.
Eingelenkt . .	9.	" " " Third.
Eingelocht . .	10.	" " " Fourth.
Eingeloest . .	11.	Forward " " Link.
Eingelullt . . .	12.	" " " Fulcrum.
Eingemacht . .	12A.	Driving " " "
Eingenaeht . .	13.	" Spring Link.
Eingeoelt . . .	14.	" " Staple.
Eingepackt . .	15.	Forward Truck Centre Pin Bolt.
Eingepicht . .	16.	Transverse Equalizing Beam.

In ordering from these plates, it is necessary to specify the figure as well as the number of piece, as it will be noticed that the same numbers have different shapes on the different figures.

Plate 31.



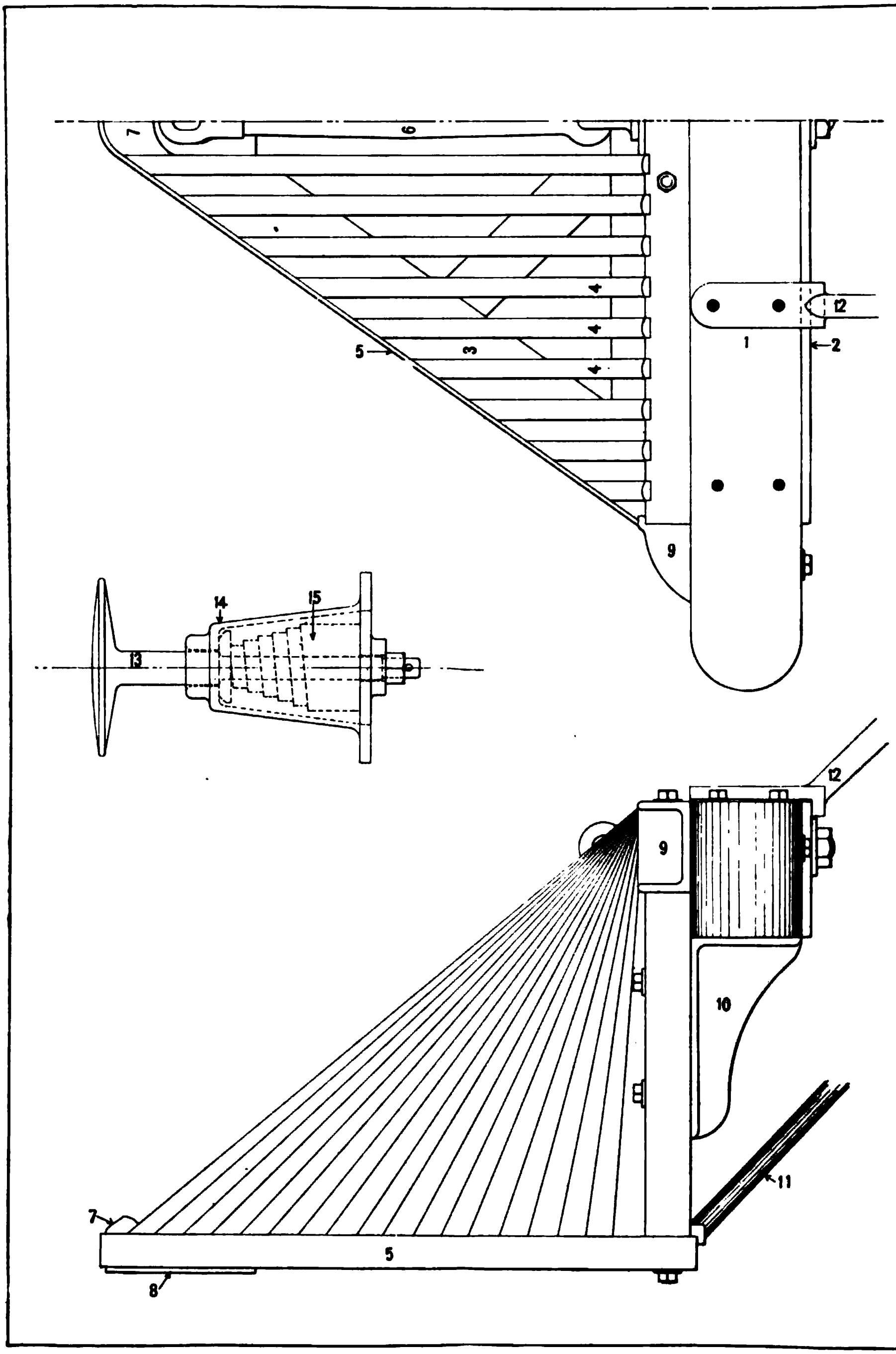
SMOKE STACKS.

Plate 31. EINGERAFFT.

Eingerahmt . . .	1. Base.
Eingesalbt	2. " Flange.
Eingesandt . . .	3. Cone.
Eingesehen . . .	4. Top.
Eingesetzt	5. Netting.
Eingittern	6. Body.
Eingreifen	7. Chamber.
Einguss	8. Inside Pipe.
Einhaekeln . . .	9. Hand Hole and Plate.

In ordering top parts of "Diamond" plan of stack, the order should always specify whether top or bottom part of No. 4 is wanted when both pieces are not required.

Plate 32.



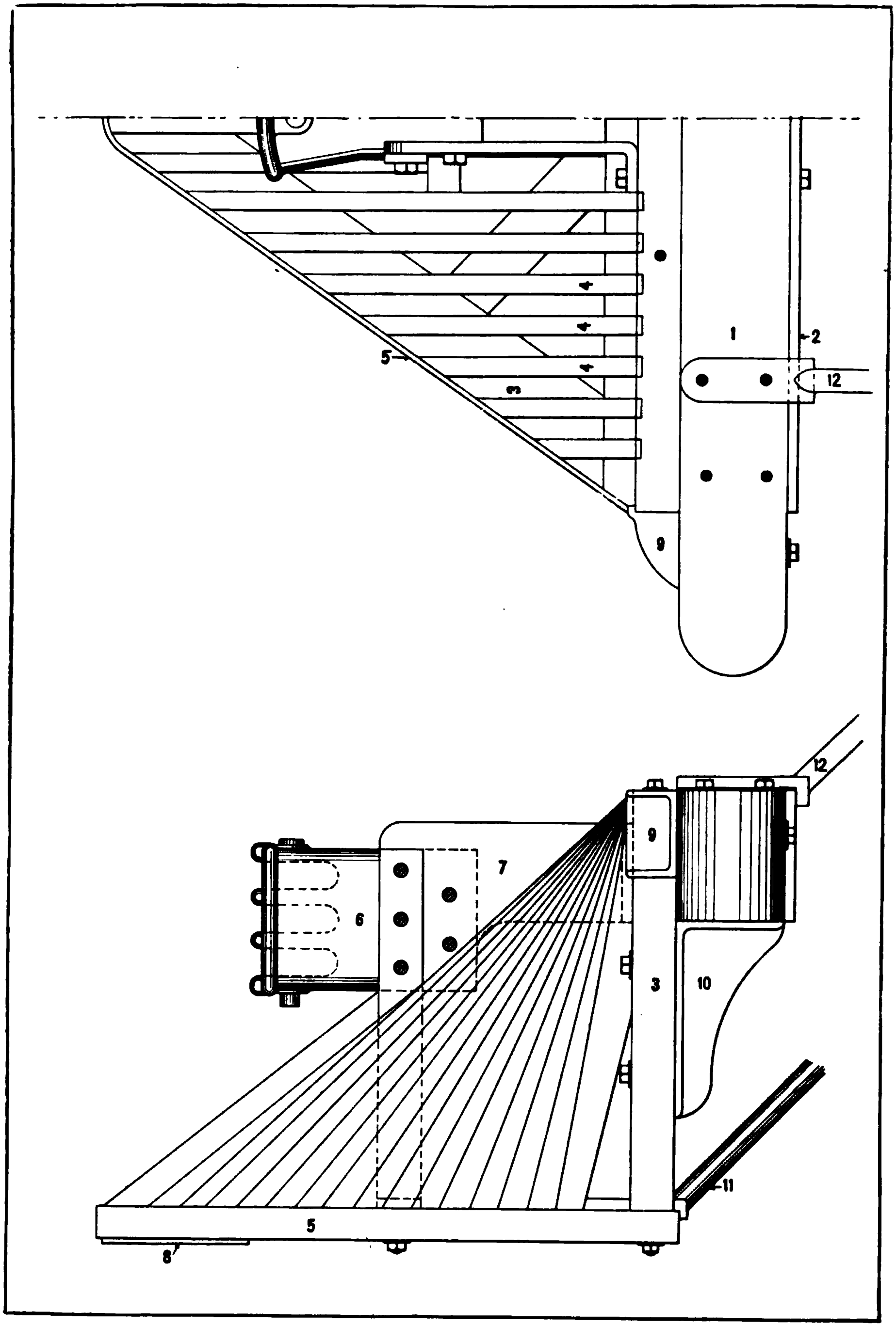
PILOT AND FRONT BUMPER, IRON DRAW BAR ATTACHMENT.

Plate 32. EINHAEUSIG.

Einhageln	1. Bumper.
Einhard	2. Stiffening Plate.
Einharken	3. Pilot Frame.
Einhegen	4. " Bars.
Einheizen	5. " Bottom Band.
Einhellig	6. Draw Bar.
Einhergang . . .	7. " " Shoe.
Einhuellen	8. Bottom Plate.
Einimpfen	9. Pushing Shoe.
Einjaehrig	10. Pilot Bracket.
Einjagen	11. Middle Brace.
Einjaket	12. Smoke Box Brace.
Einjam	13. Spring Buffer.
Einjop	14. " " Case.
Einjut	15. " " Spring.

The bracket No. 10 is made right and left, and when only one is wanted the side required for should be specified.

Plate 33.

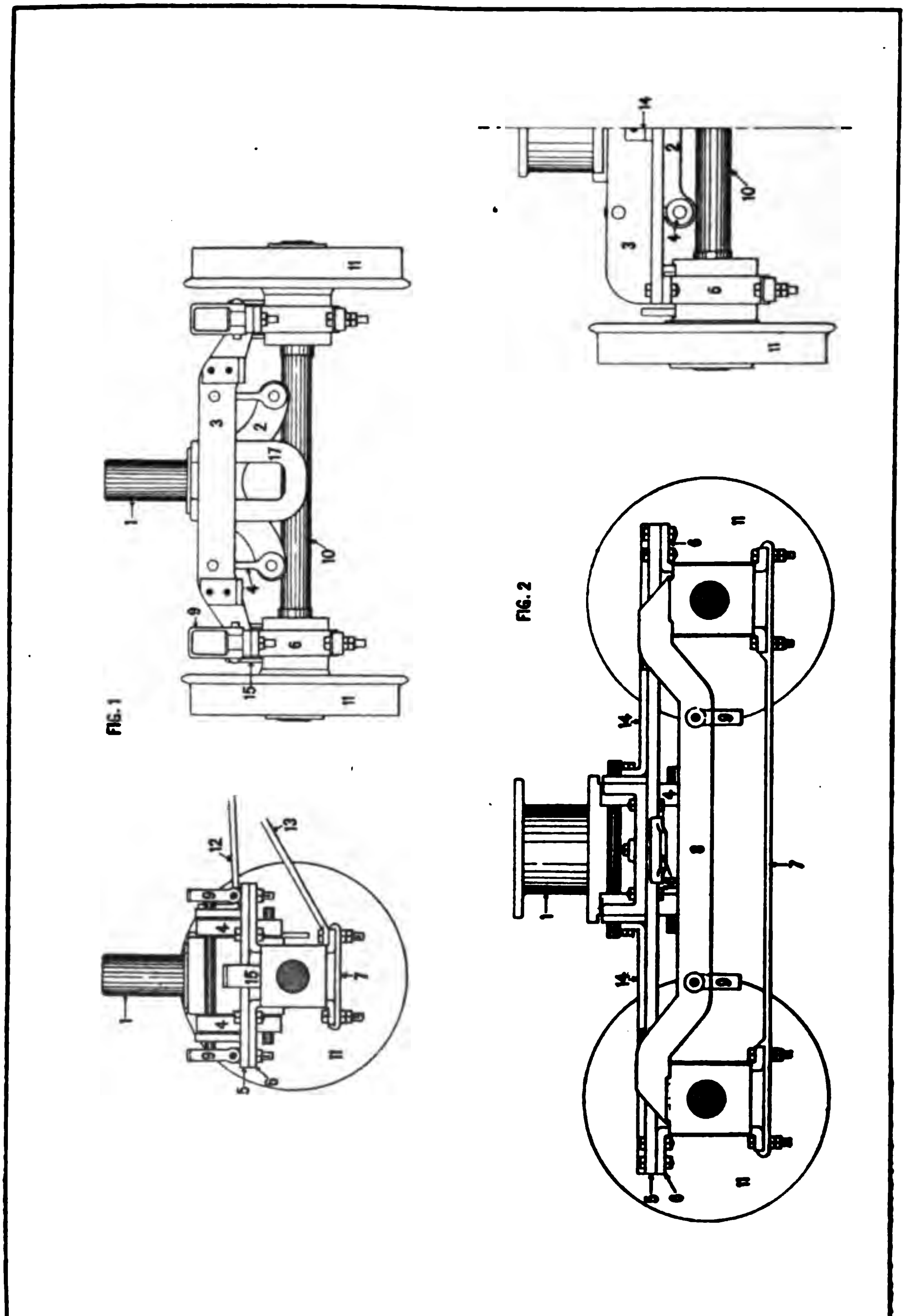


PILOT AND FRONT BUMPER, BULL NOSE ATTACHMENT.

Plate 33. EINKELTERN.

Einkrachen . .	1.	Bumper.
Einladung . . .	2.	Stiffening Plate.
Einlangen . . .	3.	Pilot Frame.
Einlappen . . .	4.	" Bars.
Einlassen . . .	5.	" Bottom Band.
Einlaut	6.	" Draw Casting.
Einlautig . . .	7.	" " " Support.
Einlenkung . .	8.	Bottom Plate.
Einliefern . . .	9.	Pushing Shoe.
Einlochen . . .	10.	Pilot Bracket.
Einloesung . .	11.	Middle Brace.
Einlomen . . .	12.	Smoke Box Brace.

Plate 34.



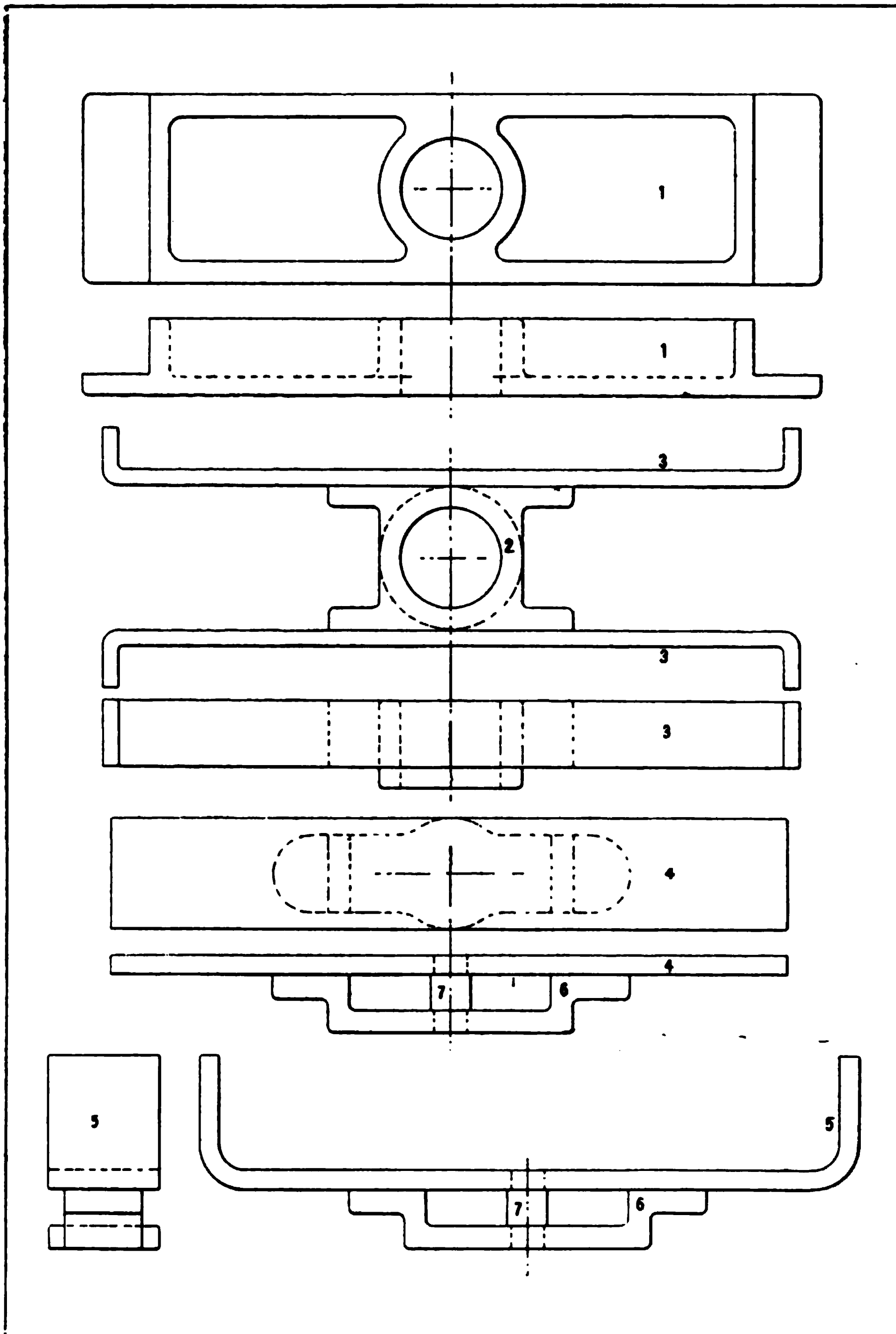
ENGINE TRUCKS.

Plate 34. EINMAHLEN.

Einmahn . . .	Fig. 1.—Two Wheeled or Pony Truck.	
Einmahnly . .	Fig. 2.—Four " Truck.	
Einmaster . . .	1.	Centre Pin.
Einmeilig . . .	2.	Swing Bolster.
Einmelken . .	3.	" " Crosstie.
Einmischen . .	4.	" " Link.
Einmuethig . .	5.	Truck Frame.
Einnahme . . .	6.	" Pedestal.
Einnarben . . .	7.	" " Cap.
Einnesteln . .	8.	Equalizing Beam.
Einnisten . . .	9.	Spring Link.
Einoede	10.	Axle.
Einoelen	11.	Wheel.
Einomenie . . .	12.	Radius Bar.
Einpaarig . . .	13.	" " Brace.
Einpacken . . .	14.	Longitudinal "
Einpichen . . .	15.	Spring Staple.
Einpoekeln . .	16.	" Seat.
Einpraegen . .	17.	Safety Strap.

This plate embodies both the pony and ordinary four-wheel truck, and in ordering parts by the designating numbers the figure number should first be given.

Plate 35.

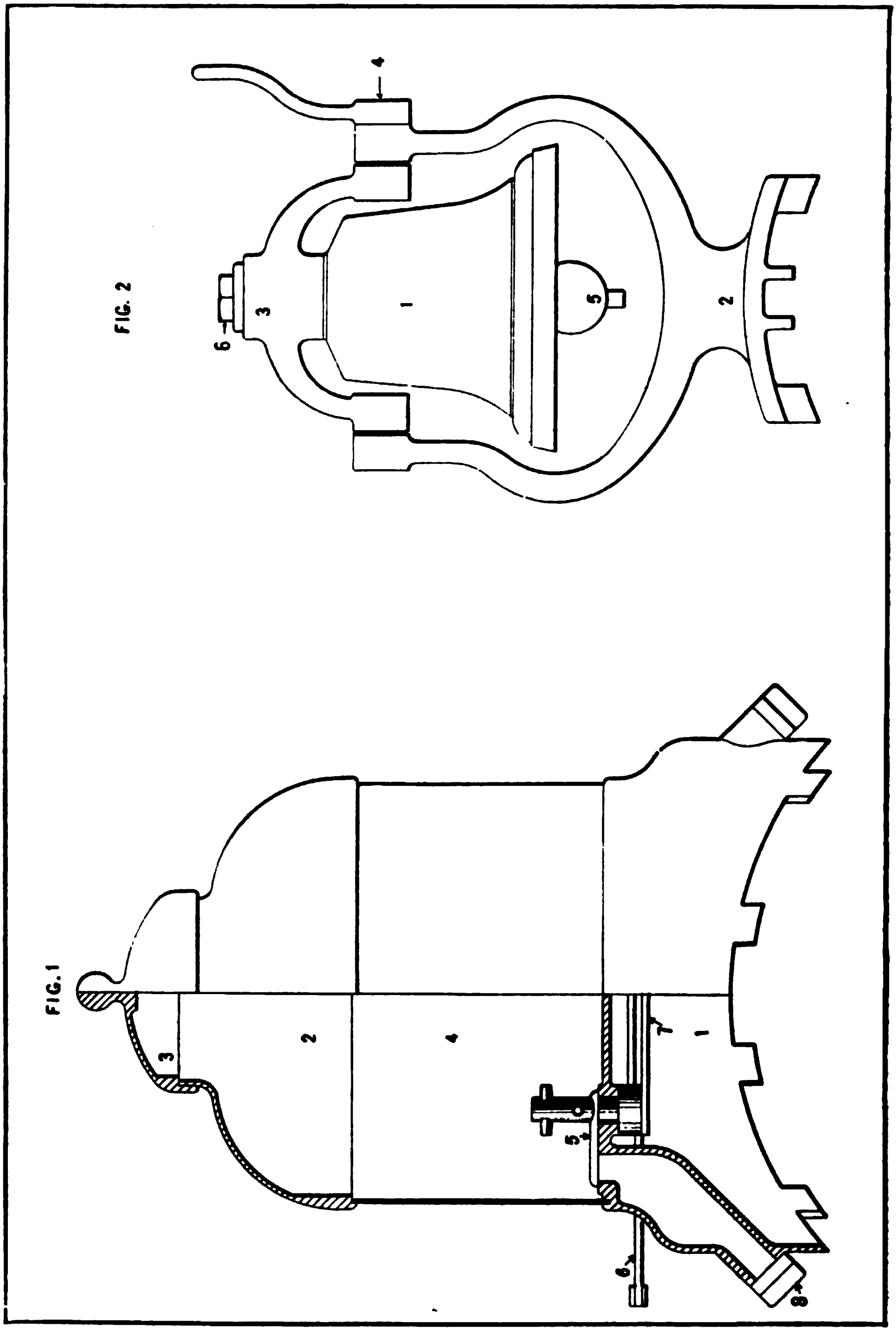


ENGINE TRUCK CENTRE PIN GUIDE AND CROSSTIE, RADIUS BAR CROSSTIE AND CLAMP.

Plate 35. EINRAFFEN.

Einrahmen	1.	Engine Truck Centre Pin Guide.
Einrammeln . . .	2.	" " " " "
Einraunen	3.	" " " " " Crosstie.
Einreiten	4.	" " Radius Bar Crosstie.
Einrippig	5.	" " " " "
Einrollbar	6.	" " " " Clamp.
Einrosten	7.	" " " " Pin.

Plate 36



SAND BOX AND BELL WORK.

Plate 36. EINRUDERN.

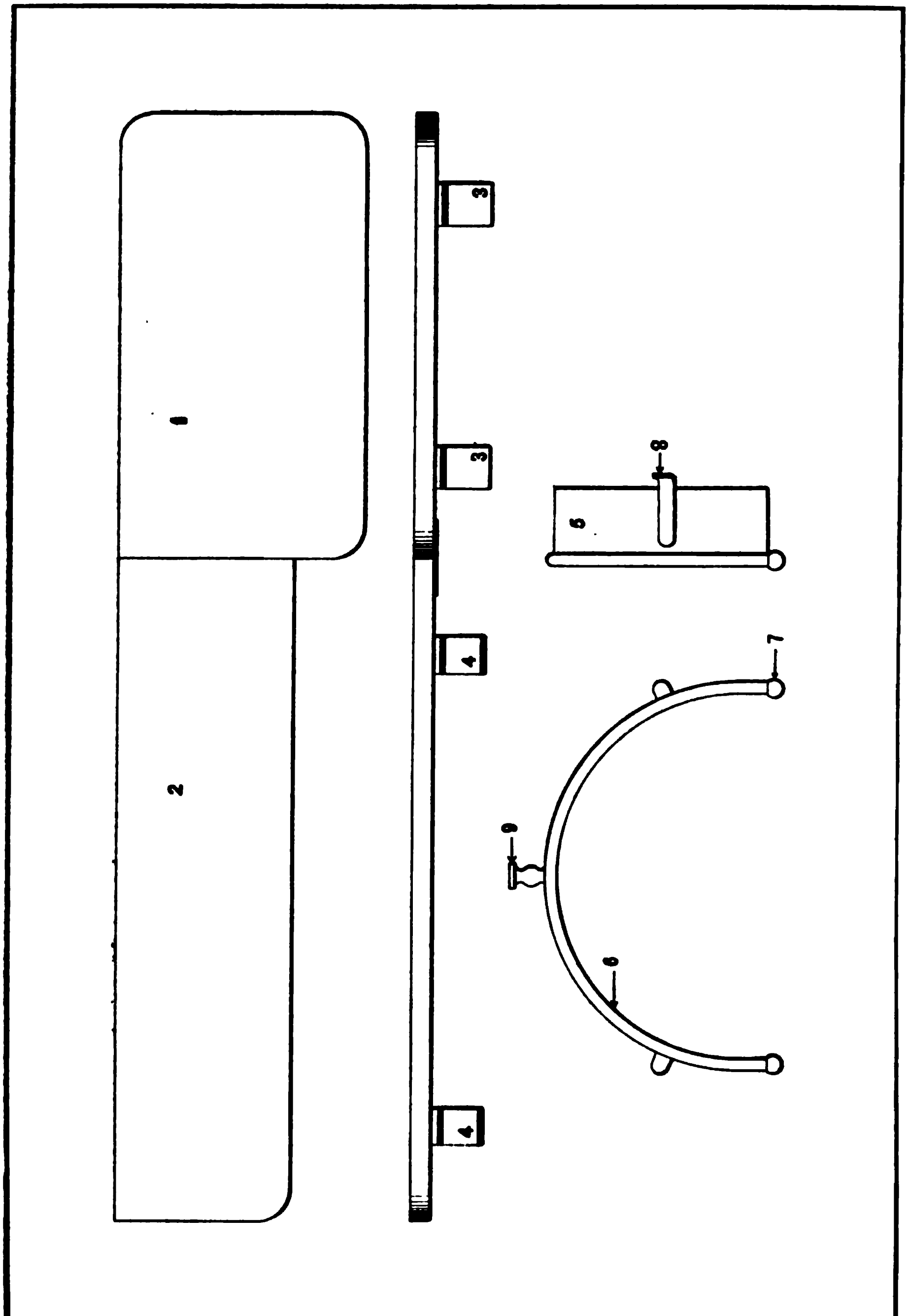
Einsalzend . . . . Fig. 1.—Sand Box.

Einsam . . . . . 1. Base.
Einsamig . . . . 2. Top.
Einsargen . . . 3. Lid.
Einsatz . . . . . 4. Body.
Einschlag . . . 5. Valve.
Einschlupf . . . 6. Lever.
Einseifen . . . . 7. Valve Connecting Rod.
Einsetzen. . . . 8. Pipe Flange.

Einspannen . . . . Fig. 2.—Bell and Frame.

Einspruch . . . 1. Bell.
Einsteigen . . . 2. Frame.
Einstig . . . . . 3. Yoke.
Einstmals . . . 4. Crank.
Einstopfen . . 5. Tongue.
Einstreu . . . . 6. Acorn.

Plate 37.



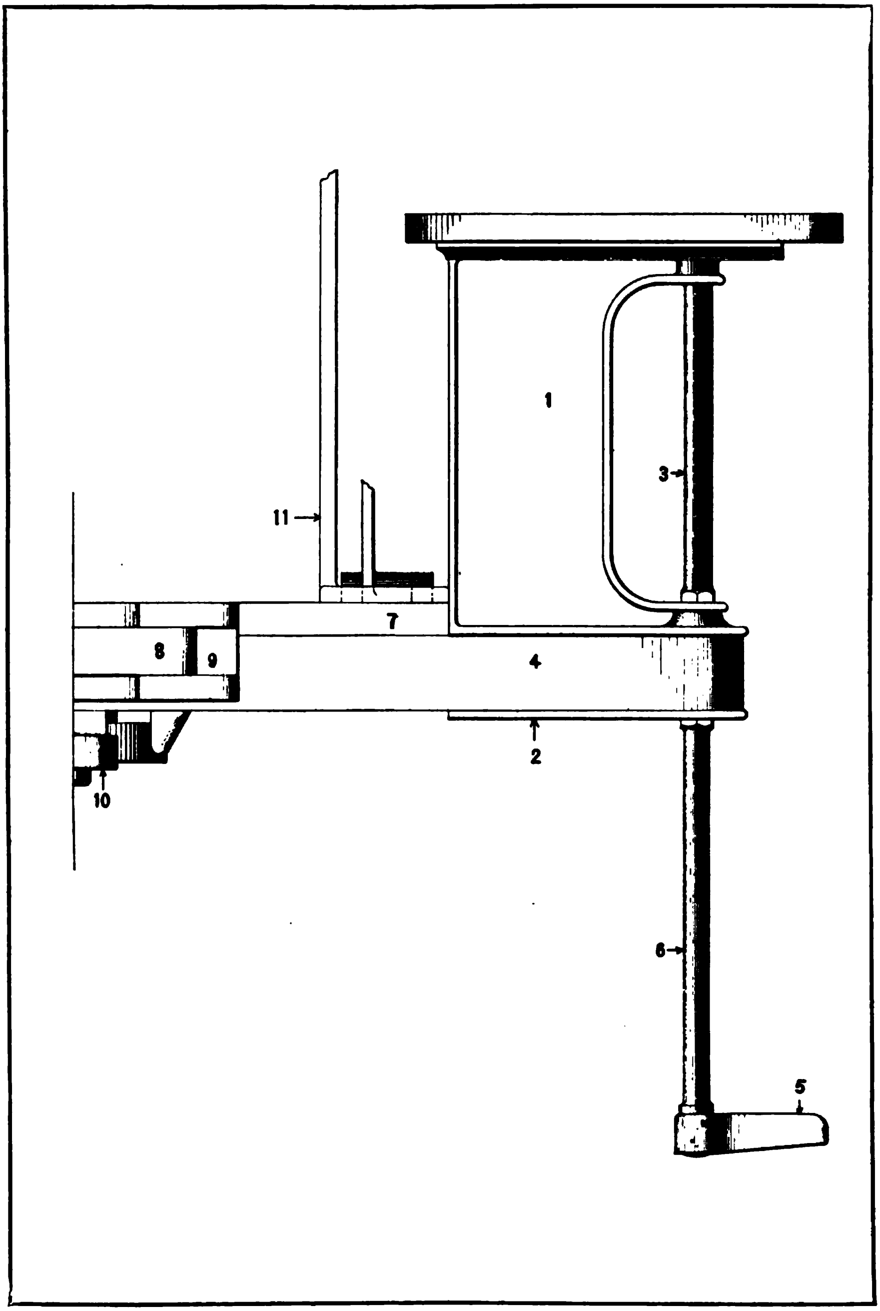
FOOT BOARDS AND WHEEL COVERS.

Plate 37. EINSTREUEN.

Einstutzen . .	1. Cab Foot Board.			
Eintaegig . . .	2. Running	"		
Eintausch . .	3. Cab Foot	"		Brackets.
Eintoenig . .	4. Running	"		"
Eintracht . . .	5. Wheel Cover.			
Einungstag . .	6.	"	"	Pipe.
Einwaerts . .	7.	"	"	Acorn.
Einzaehlig . .	8.	"	"	Bracket.
Einzahl	9.	"	"	Column.

These parts are seldom ordered except in full sets, and the side wanted for should be given when they are not so ordered.

Plate 38.



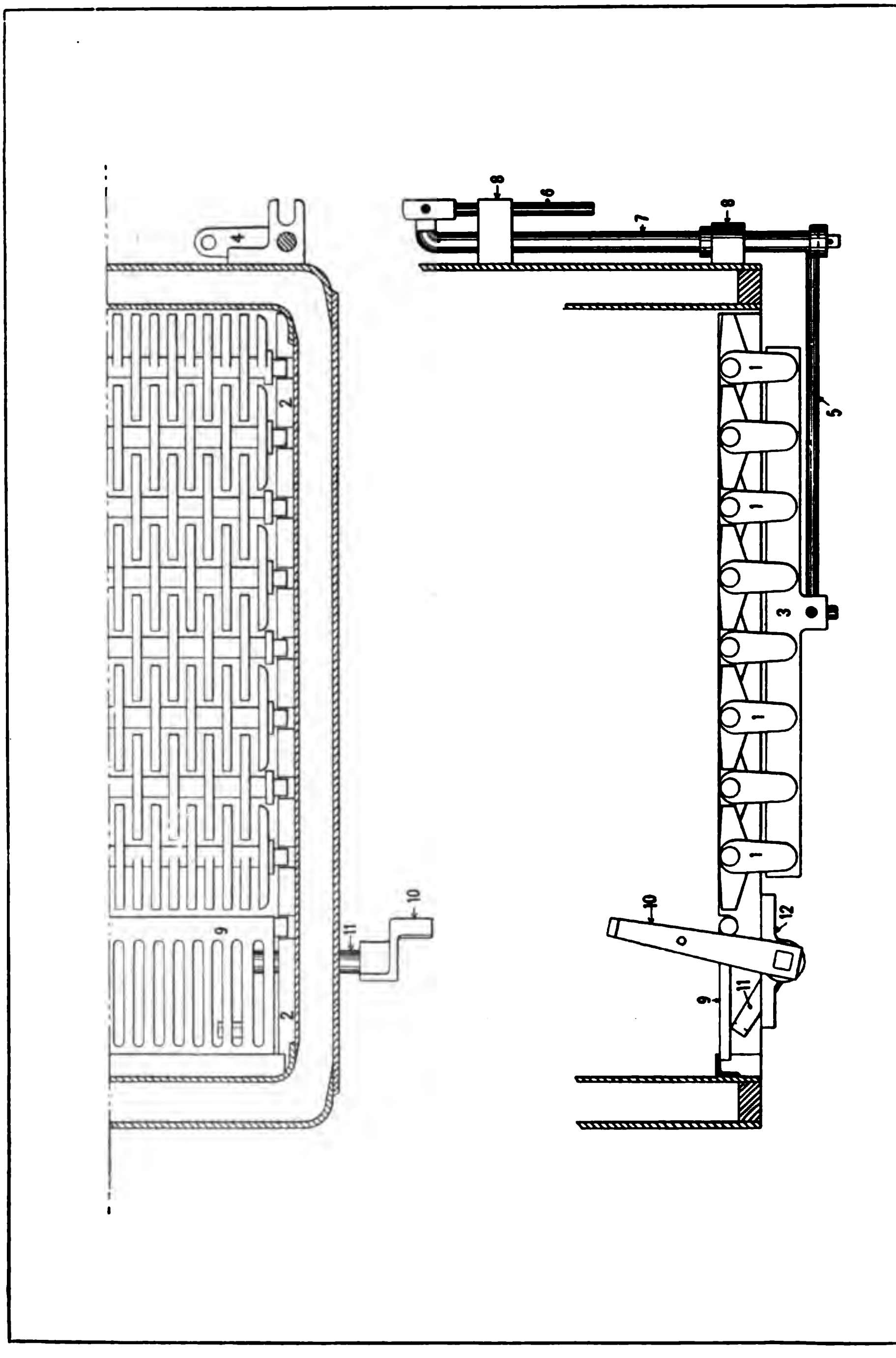
BACK BUMPER AND ATTACHMENTS.

Plate 38. EINZAHLUNG.

Einzelbach . . .	1.	Cab Bracket.
Einzelbild . . .	2.	" " Plate.
Einzeln	3.	" " Pipe.
Einzelwort . . .	4.	Back Bumper.
Einzelzug . . .	5.	Engine Step.
Einzieher	6.	" " Hanger.
Einzig	7.	Foot Plate.
Einzwingen . .	8.	Tender Wedge.
Eioneous	9.	" " Box.
Eiradego	10.	Back Draw Bar.
Eiresto	11.	Back Brace.

Cab brackets are made right and left. Orders for single brackets should give side wanted for.

Plate 39.



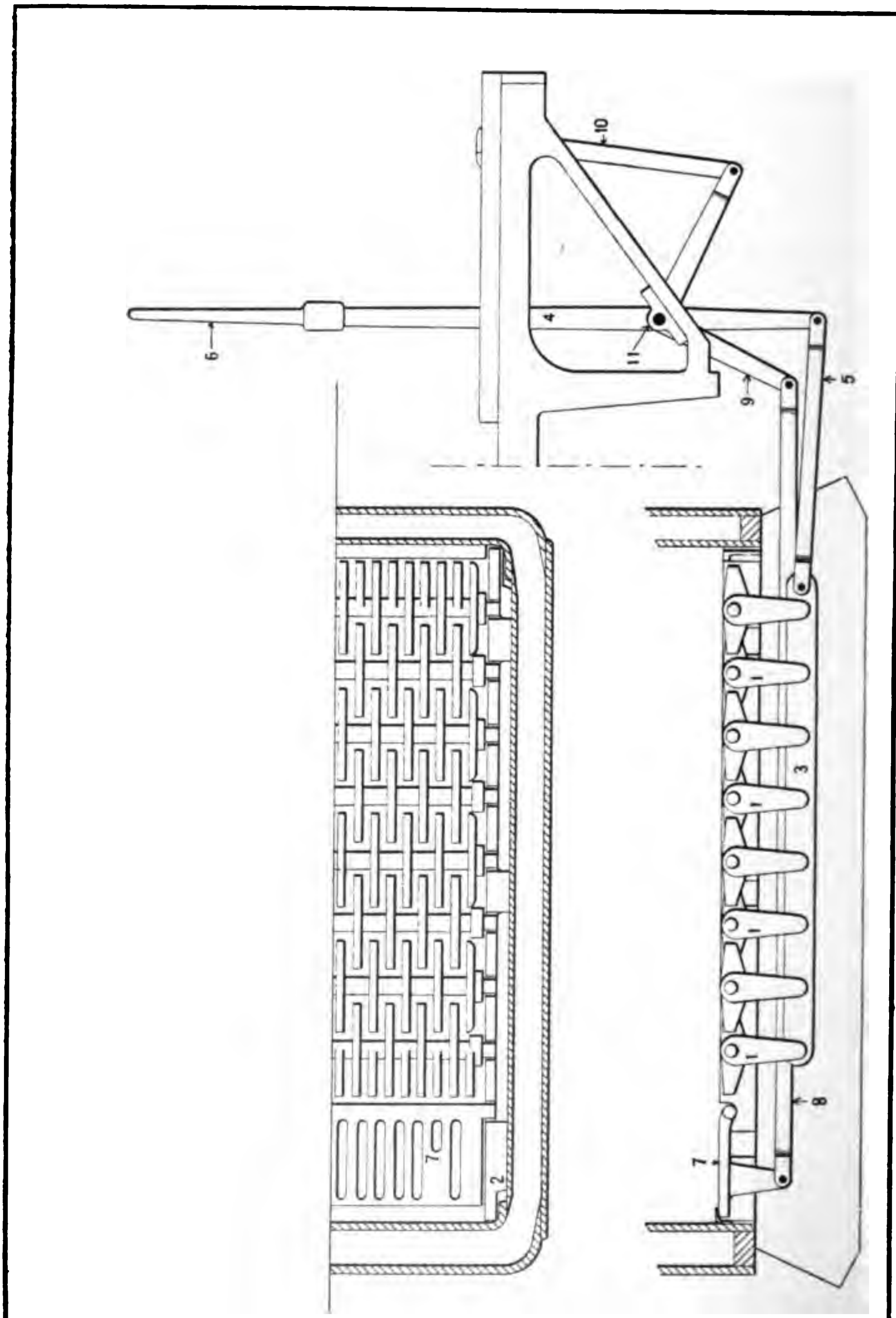
ROCKING GRATE WORK.

Plate 39. EIRENARCH.

Eirund	1.	Bar.
Eisachat . . .	2.	Frame.
Eisbaelle . . .	3.	Connecting Bar.
Eisbaertig . .	4.	Arm.
Eisbahn	5.	Rod.
Eisbank	6.	Handle.
Eisbecher . . .	7.	Shaft.
Eisberg	8.	" Bearings.
Eisbergen . . .	9.	Drop Plate.
Eisblock . . .	10.	" " Handle.
Eisblume . . .	11.	" " Shaft.
Eisch	12.	" " " Bearing.

When complete sets of these bars are not wanted, the order should give the position from the front, of the bars that are required.

Plate 40.



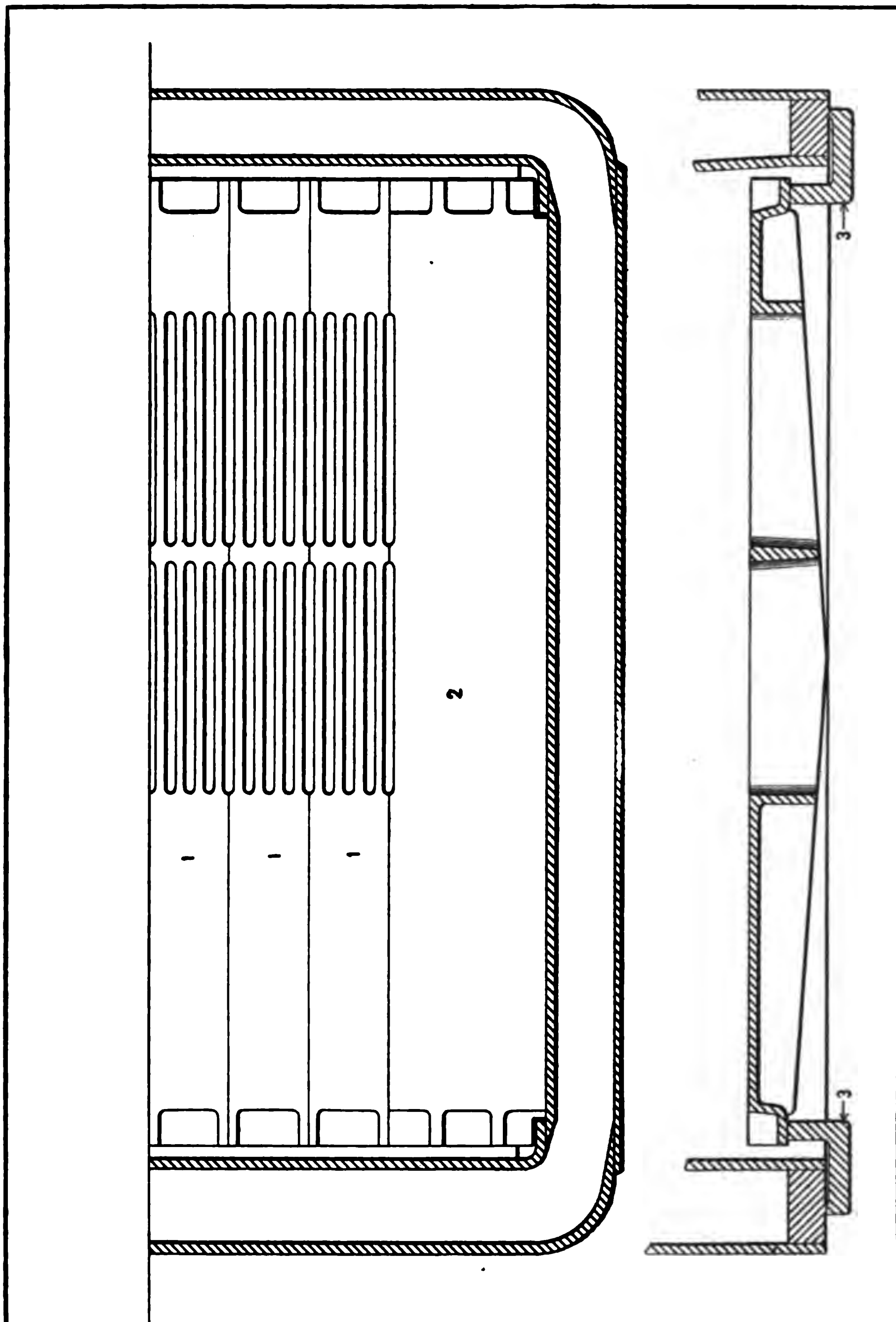
ROCKING GRATE WORK.

Plate 40. EISCHENDE.

Eiseiche. . . .	1.	Bar.			
Eisenader. . .	2.	Frame.			
Eisenalaun . .	3.	Connecting Bar.			
Eisenbarre . .	4.	Lever.			
Eisenerz . . .	5.	"	Rod.		
Eisenfest . . .	6.	"	Handle.		
Eisenfleck . .	7.	Drop Plate.			
Eisengang . .	8.	"	"	Rod.	
Eisengeld . . .	9.	"	"	Crank.	
Eisenglanz . .	10.	"	"	"	Handle.
Eisengrube . .	11.	"	"	"	Bearing.

When complete sets of these bars are not wanted, the order should give the position from the front, of the bars that are required.

Plate 41.



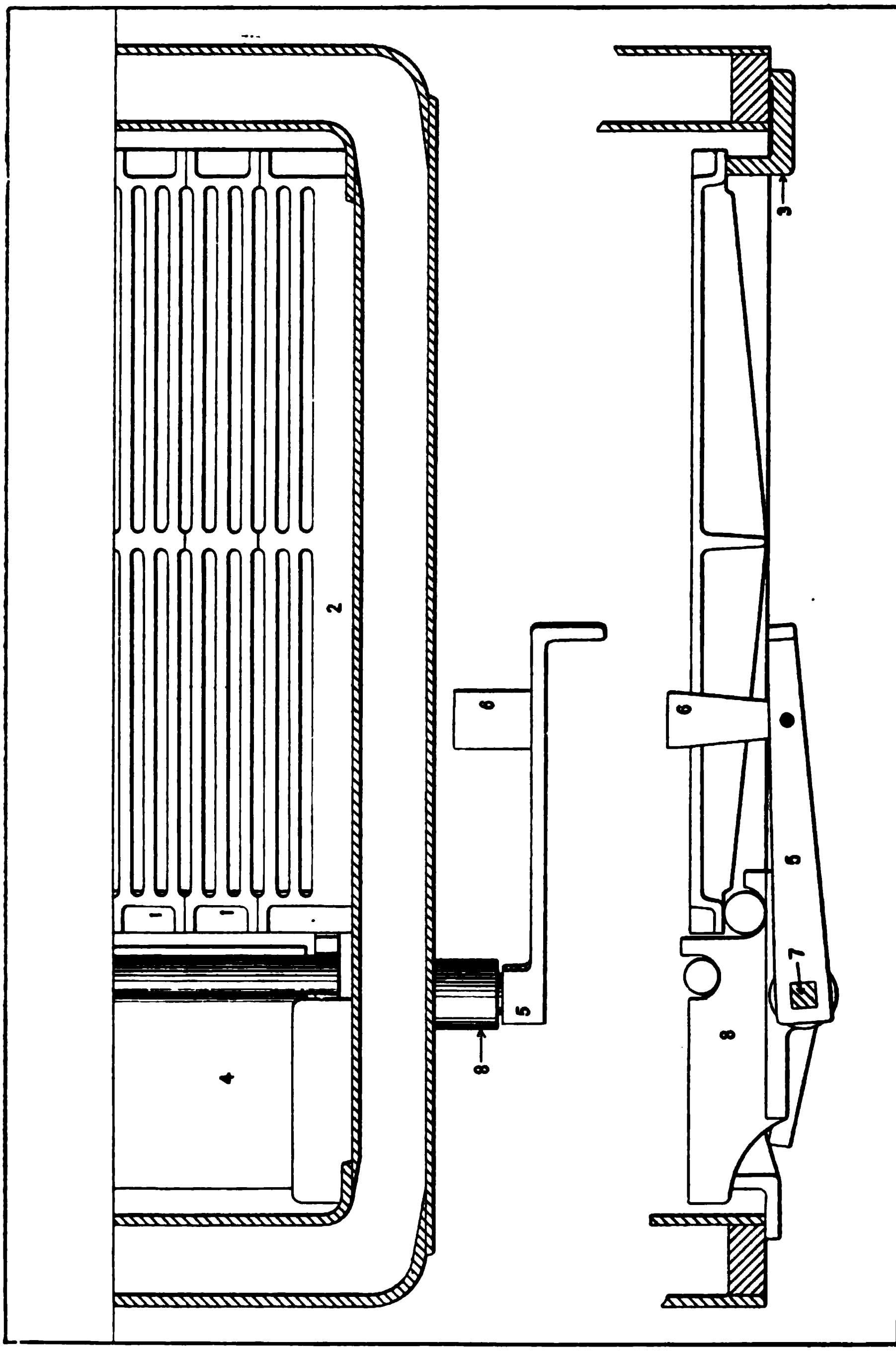
PLAIN GRATE FOR WOOD.

Plate 41. EISENHAKEN.

Eisenholz . .	1. Bar.
Eisenhose . .	2. Dead Plate.
Eisenjoch . .	3. End Holder.

For this plan of grate it will be necessary to specify the side dead plate is required for when not in full sets.

Plate 42.



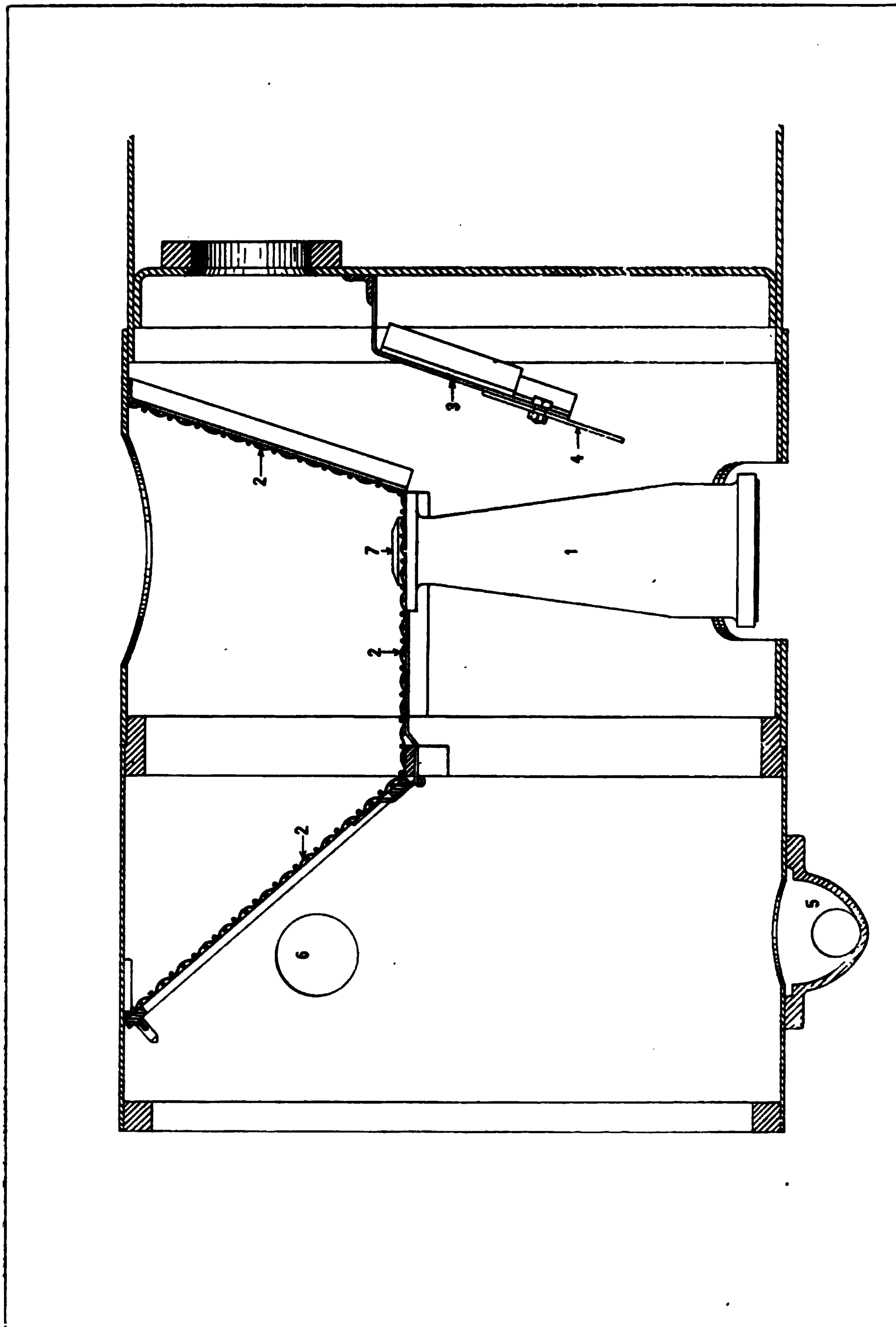
PLAIN GRATE FOR SOFT COAL.

Plate 42. EISENKALK.

Eisenkeil . . .	1. Bar.				
Eisenklaue . .	2. Dead Plate.				
Eisenmauer. .	3. End Holder.				
Eisenmohr . .	4. Drop Plate.				
Eisenmulm . .	5.	"	"	Handle.	
Eisennuss. . .	6.	"	"	"	Support.
Eisenocher . .	7.	"	"	Shaft.	
Eisenofen. . .	8.	"	"	"	Bearing.

The bearings for drop plate shaft are made right and left. This should be observed in ordering duplicates.

Plate 43.



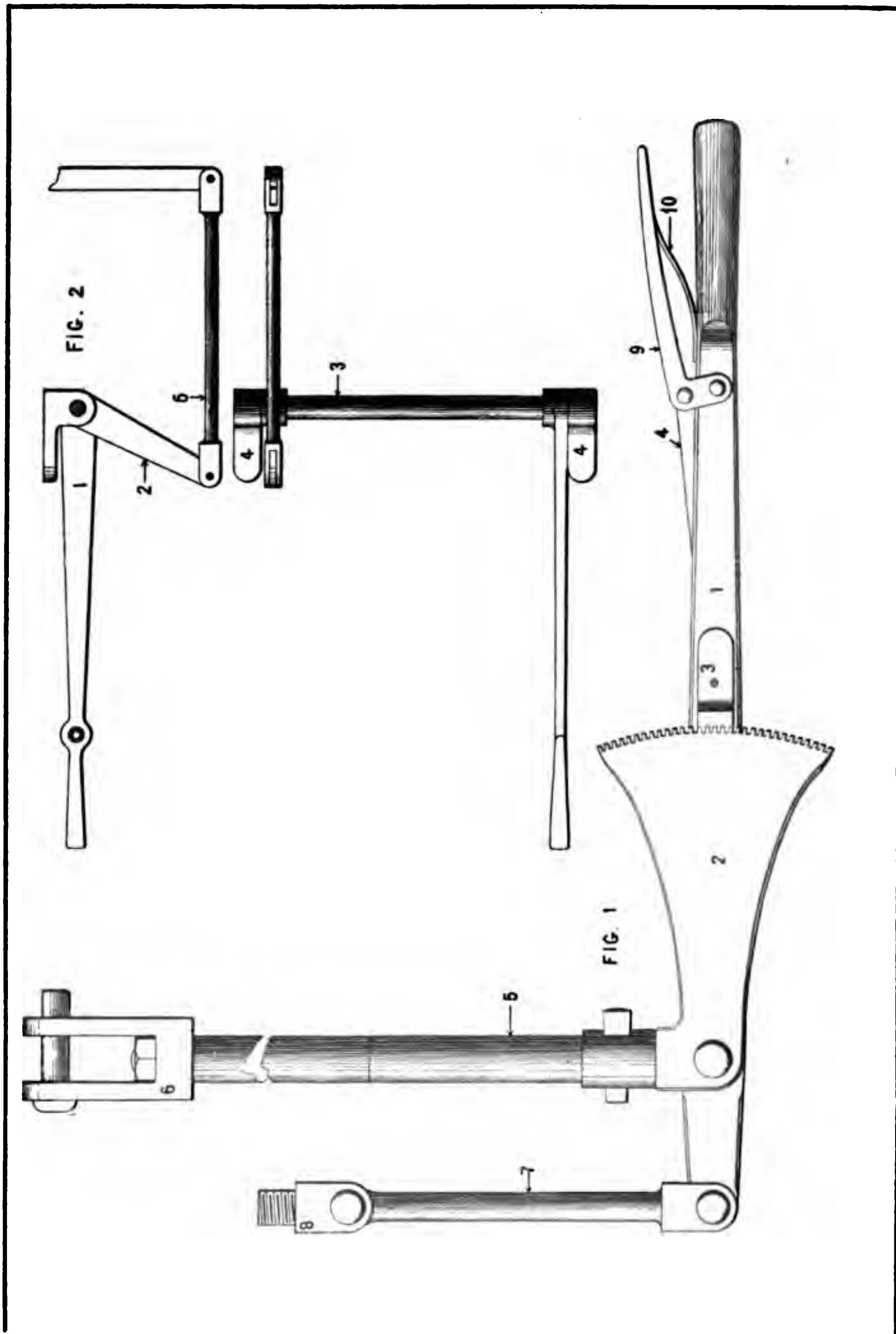
SMOKE BOX FITTINGS.

Plate 43. EISENOPAL.

Eisenprobe . . .	1. Exhaust Nozzle.
Eisenrahm . . .	2. Netting.
Eisenring	3. Deflecting Plate.
Eisenrost	4. " " Slide.
Eisensalz	5. Spark Ejector.
Eisensand. . . .	6. Cleaning Hole and Cap.
Eisenschuh . . .	7. Exhaust Thimbles.

In ordering these parts, if any change is required from original fittings, especially with reference to nozzle, the order should specify whether single or double opening is wanted. Thimbles always include three sizes to a set, and the particular size wanted, when not in full sets, should be given.

Plate 44.



THROTTLE AND WHISTLE WORK.

Plate 44. EISENSPITZ.

Eisensporn . . . . Fig. 1.—Throttle Work.

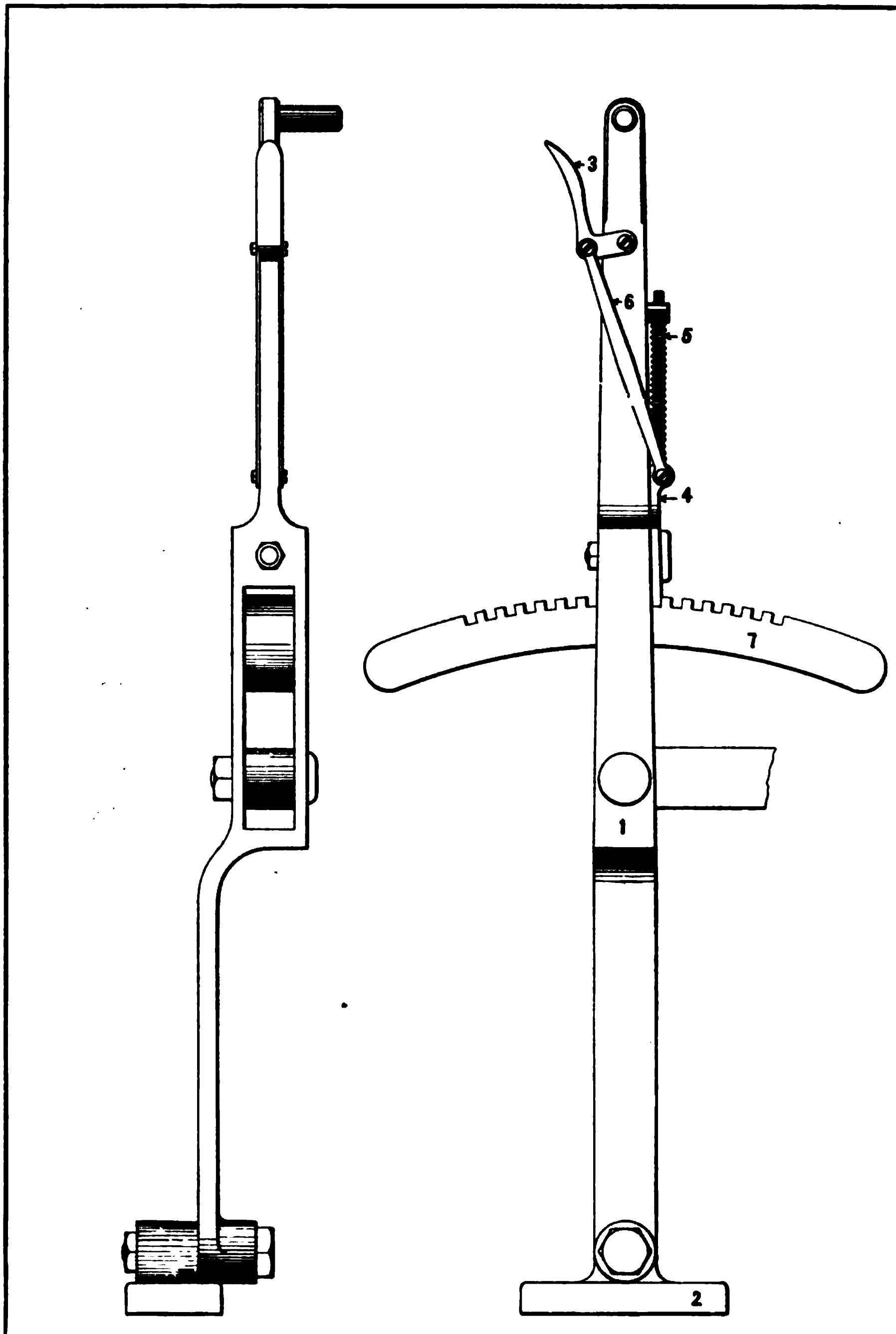
Eisenstark	1.	Lever.
Eisenstaub	2.	Quadrant.
Eisenstich	3.	Latch.
Eisenstufe	4.	" Link.
Eisenthor	5.	Rod.
Eisenthurm . . .	6.	Jaw.
Eisentritt	7.	Link.
Eisentruhe	8.	" Stud.
Eisenwaare . . .	9.	Handle.
Eisenwaffe . . .	10.	" Spring.

Eisenzahn . . . . Fig. 2.—Whistle Work.

Eisenzeit	1.	Lever.
Eisenzeug	2.	Arm or Crank.
Eisenzoll	3.	Shaft.
Eiseshauch . . .	4.	" Bearing.
Eisfloh	5.	Link.

In ordering Link No. 5, Fig. 2, the distance from centre to centre of jaw should be given.

Plate 45.

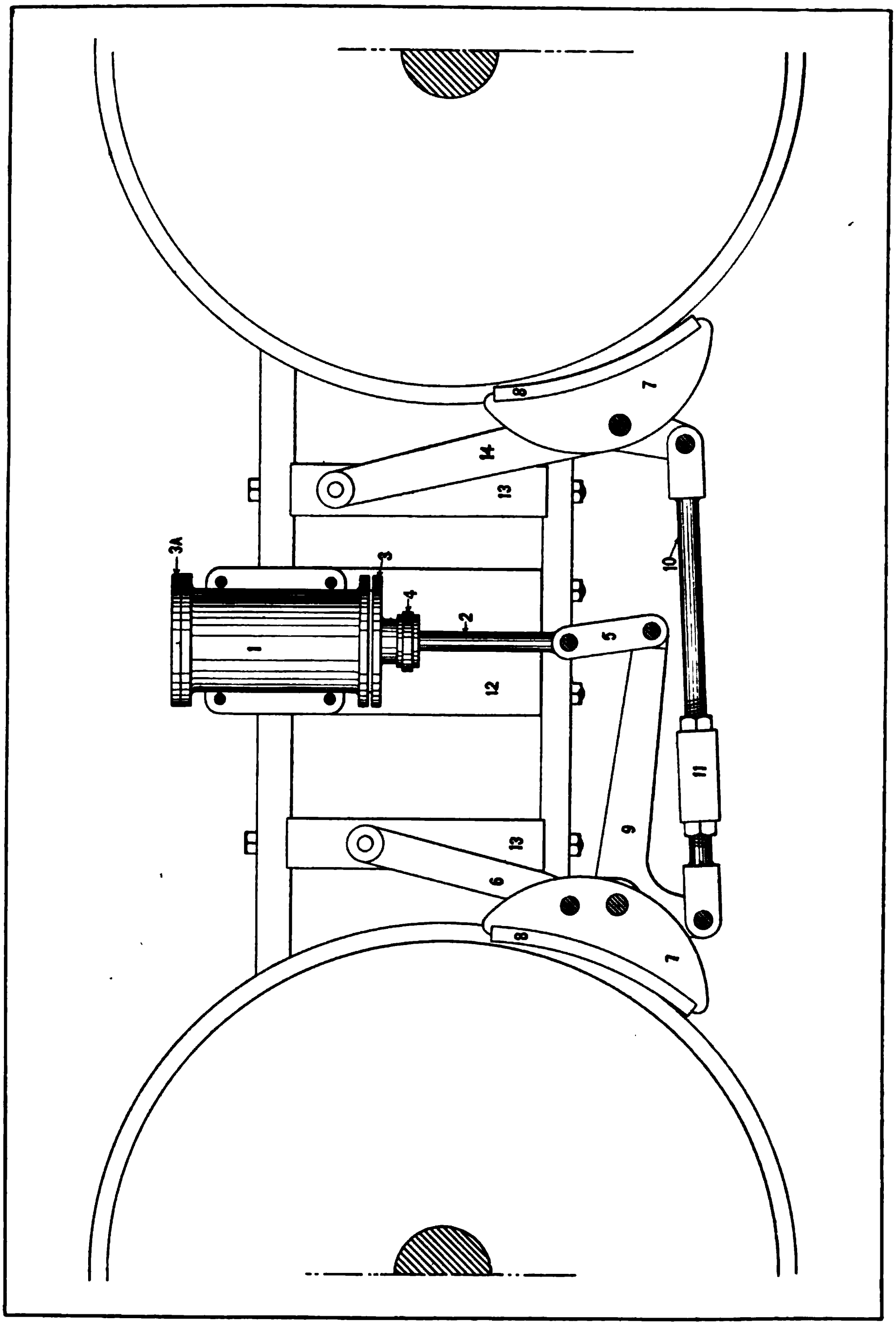


REVERSE LEVER AND ATTACHMENTS.

Plate 45. EISFUCHS.

Eisgang	1. Lever.
Eisgipfel	2. Fulcrum.
Eisgrau	3. Handle.
Eishoehle	4. Latch.
Eishund	5. " Spring.
Eisinsel	6. " Rod.
Eiskaelte	7. Catch.

Plate 46.



STEAM BRAKE WORK.

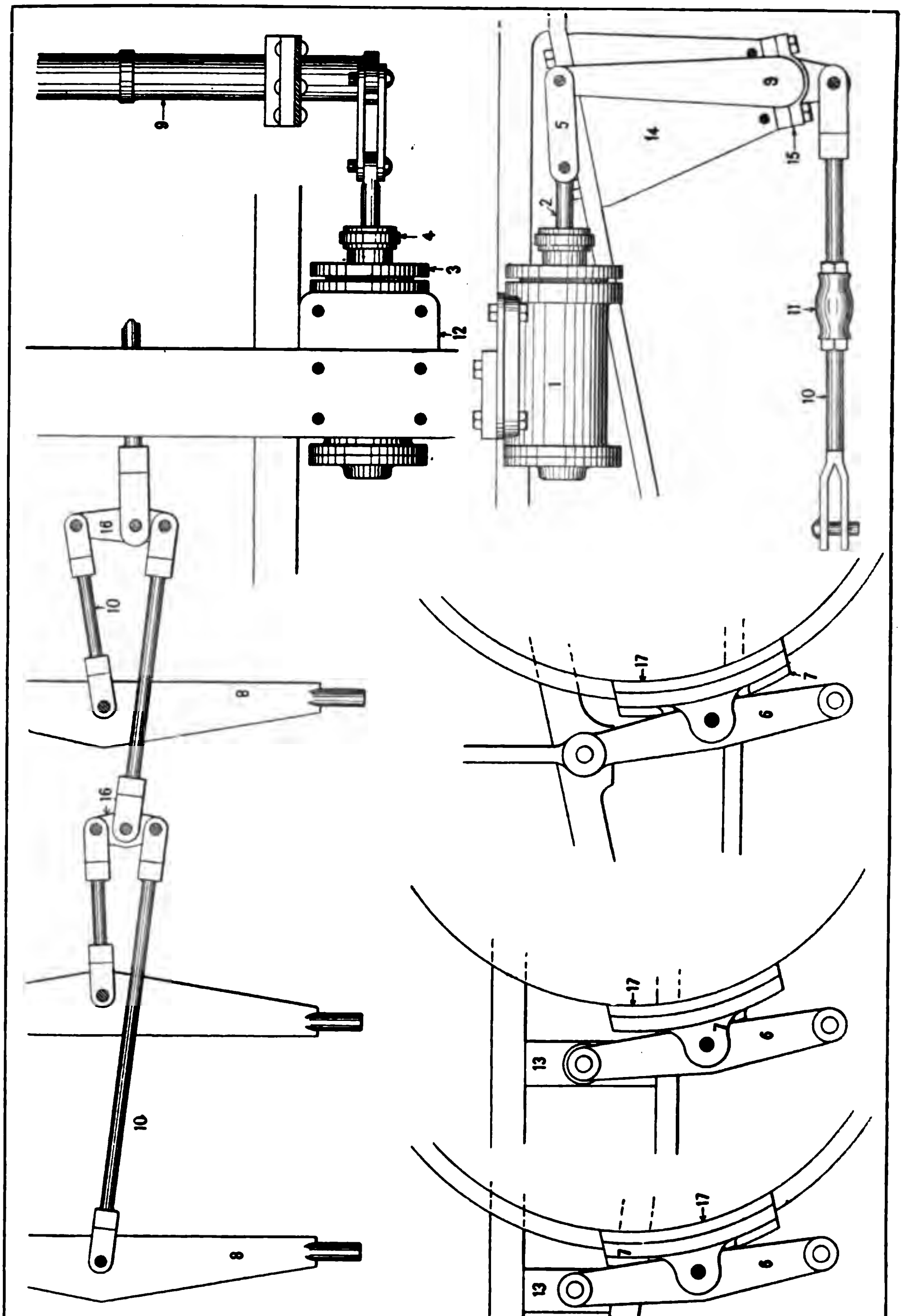
SPREAD STYLE.

Plate 46. EISKEGEL.

Eiskeller	1.	Brake Cylinder.		
Eiskessel	2.	"	Piston Rod.	
Eiskluft	3.	"	Cylinder Head, Bottom.	
Eisklumpen . .	3A.	"	" "	Top.
Eislaeufer . . .	4.	"	"	Stuffing Box Nut.
Eislawine . . .	5.	"	Connecting Link.	
Eisloch	6.	"	Hanger Link.	
Eismeer	7.	"	Head.	
Eismoewe . . .	8.	"	Shoe.	
Eismonat	9.	"	Bell Crank.	
Eismuetze . . .	10.	"	Rod.	
Eisnadel	11.	"	"	Adjusting Nut.
Eisnetz	12.	"	Cylinder Support.	
Eispalast	13.	"	Hanger "	
Eispflug	14.	"	Lever.	

Separate catalogues of patented power brakes may be obtained by applying to the makers.

Plate 47.



STEAM BRAKE WORK.

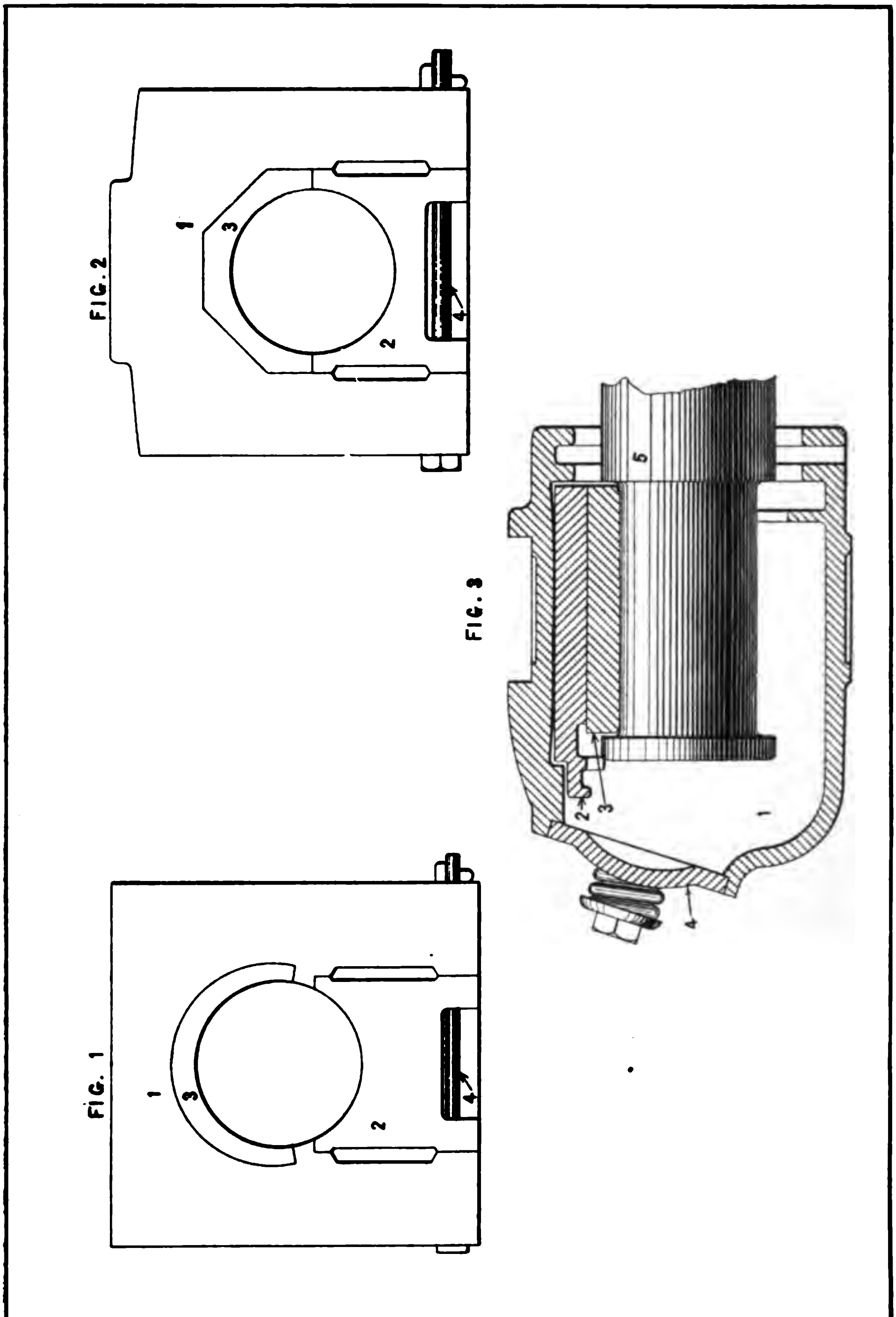
EQUALIZED STYLE.

Plate 47. EISPNOIQUE.

Eispol	1.	Brake Cylinder.	
Eispunkt	2.	"	Piston Rod.
Eisrechen . . .	3.	"	Cylinder Head.
Eisrevier	4.	"	" Stuffing Box Nut.
Eisriegel	5.	"	Connecting Link.
Eisrinde	6.	"	Lever.
Eissamp	7.	"	Head.
Eissaugue . . .	8.	"	Beam.
Eisschuh	9.	"	Shaft.
Eisspitzen . . .	10.	"	Rod.
Eissporn	11.	"	" Adjusting Nut.
Eisstoss	12.	"	Cylinder Support.
Eisstrom	13.	"	Hanger.
Eissturz	14.	"	Shaft Support.
Eistafel	15.	"	" Bearing.
Eistanz	16.	"	Rod Lever.
Eisteddfod . . .	17.	"	Shoe.

Separate catalogues of patented power brakes may be obtained by applying to the makers.

Plate 48.



JOURNAL BOXES.

Plate 48. EISTHAU.

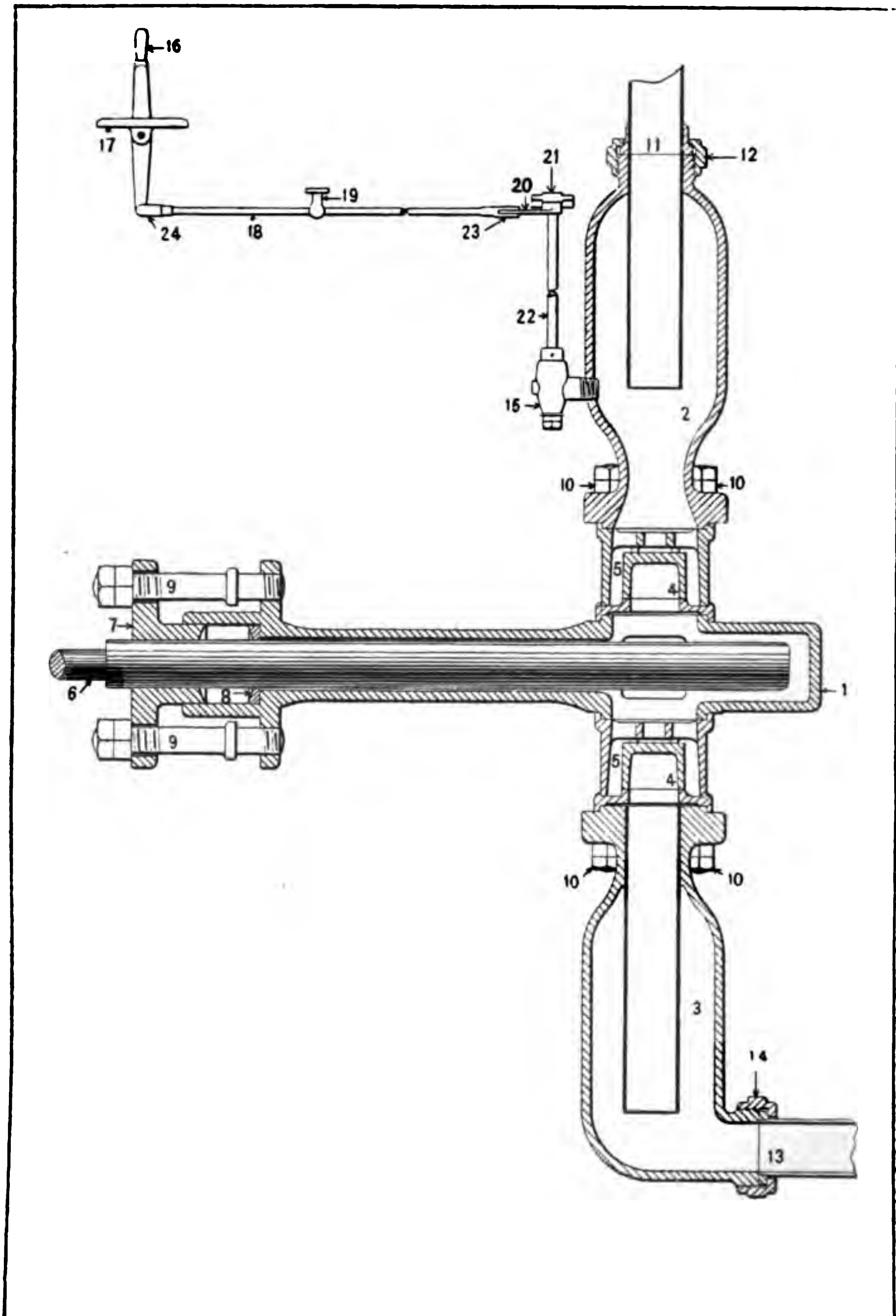
Eisthorm . . . . Fig. 1.—Driving Box.
Eisthormly . . . Fig. 2.—Truck "

Eistropfen . . 1. Box.
Eisufer . . . . 2. Cellar.
Eisvogel . . . 3. Brass.
Eiswand . . . 4. Cellar Bolt.

Eiswasser . . . . Fig. 3.—Tender Box.

Eiswelt . . . . 1. Box.
Eiswolke . . . 2. Wedge.
Eiswurm . . . 3. Brass.
Eiszacken . . 4. Lid.
Eiszapfen . . . 5. Axle.

Plate 49.



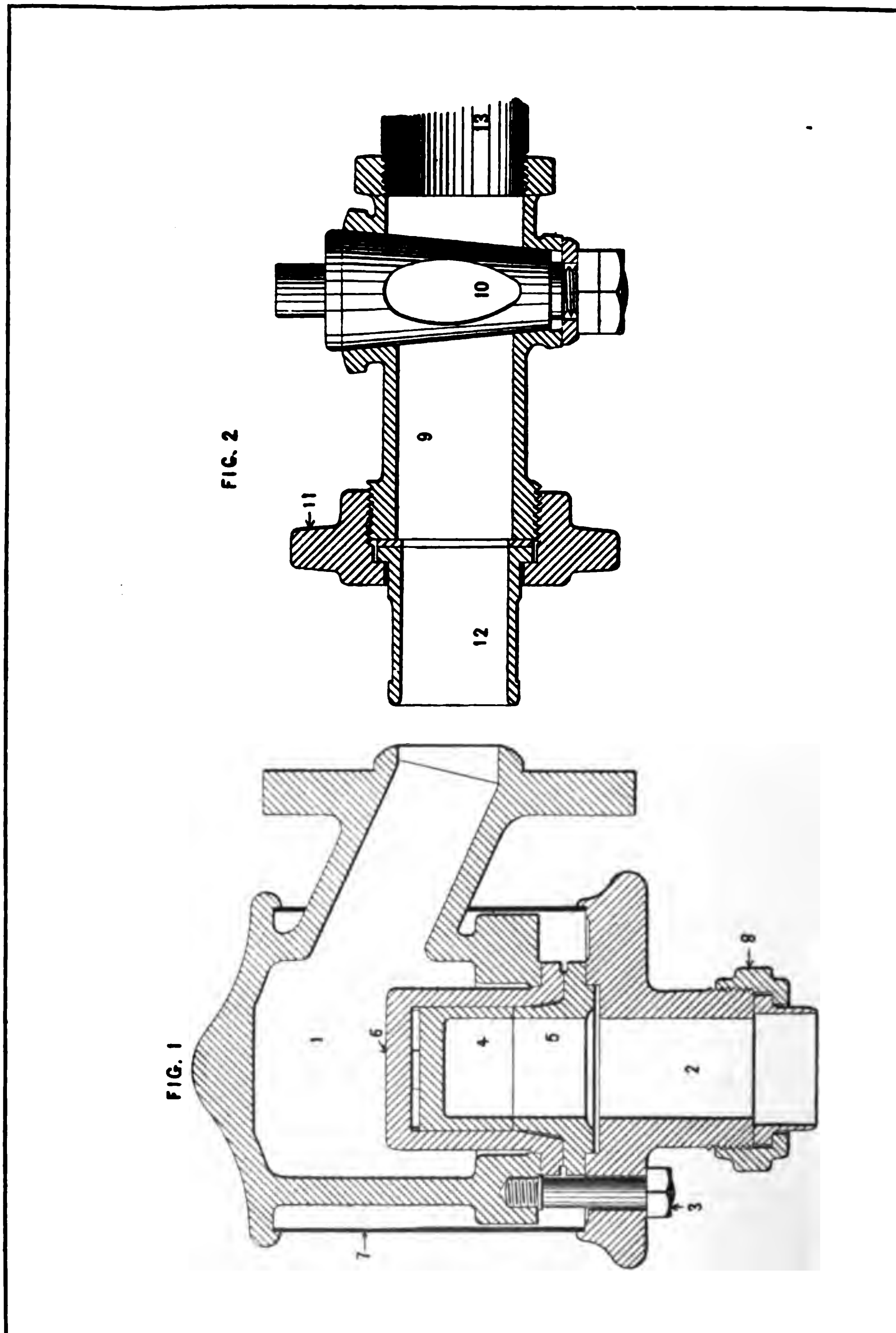
PUMP WORK.

Plate 49. EISZONE.

Eitelhans	1.	Pump Barrel.
Eitelkeit	2.	Top Chamber.
Eitelsucht	3.	Bottom Chamber.
Eiterbeule	4.	Valve.
Eiterblase	5.	" Cage.
Eiterig	6.	Plunger.
Eiterperle	7.	Gland.
Eitjes	8.	" Bottom Ring.
Eiulazione	9.	" Studs.
Eivol	10.	Chamber Studs.
Eivormig	11.	Check Pipe.
Eiweiss	12.	" " Coupling Nut.
Eiwit	13.	Feed Pipe.
Eiwitstof	14.	" " Coupling Nut.
Eiwitten	15.	Pet Cock.
Eixerdar	16.	" " Lever in Cab.
Ejaculacao	17.	" " " Fulcrum.
Ejaculador	18.	" " " Rod.
Ejaculamur	19.	" " " " Guide.
Ejacular	20.	" " Crank.
Ejacularis	21.	" " " Hanger.
Ejaculavi	22.	" " " Rod.
Ejaculo	23.	" " " Jaw.
Ejambe	24.	" " Lever "

In ordering pump barrel, the side wanted for should be indicated in the order.

Plate 50.



PUMP CHECK AND FEED COCK.

Plate 50. EJARRAGE.

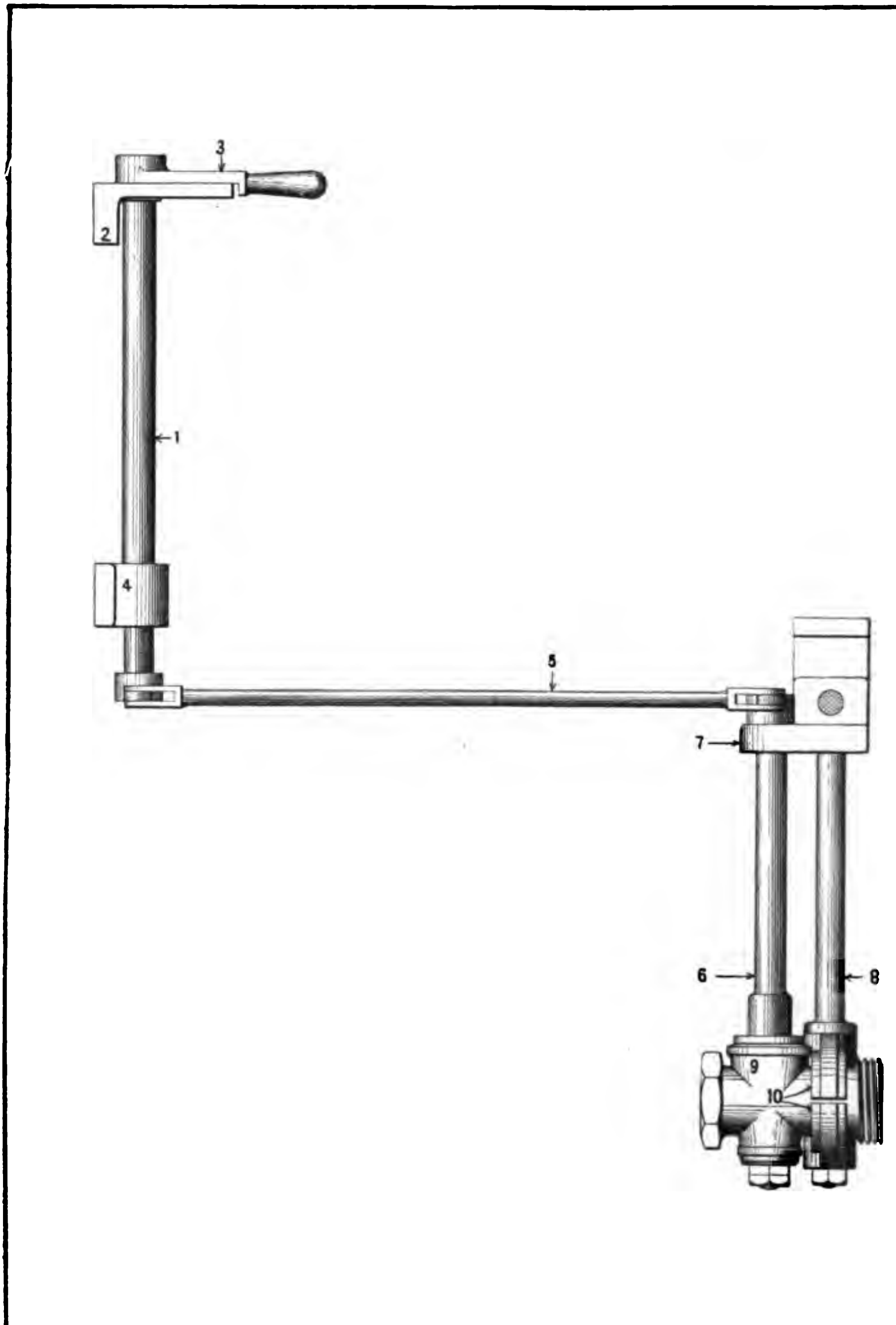
Ejarre . . . . . Fig. 1.—Pump Check.

Ejeccao . . .	1.	Check Body.
Ejecimus . .	2.	" Flange.
Ejecissem . .	3.	" " Studs.
Ejecteur . . .	4.	Valve.
Ejecticio . . .	5.	" Seat.
Ejecticius . .	6.	" Cage.
Ejectments .	7.	Casing.
Ejectura . . .	8.	Check Pipe Coupling Nut.

Ejecturis . . . . Fig. 2.—Feed Cock.

Ejectuum . .	9.	Feed Cock Body.
Ejecucion . .	10.	" " Plug and Nut.
Ejecutada . .	11.	Hose Coupling Nut.
Ejecutados .	12.	" Swivel.
Ejecutar . . .	13.	Feed Pipe.

Plate 51.

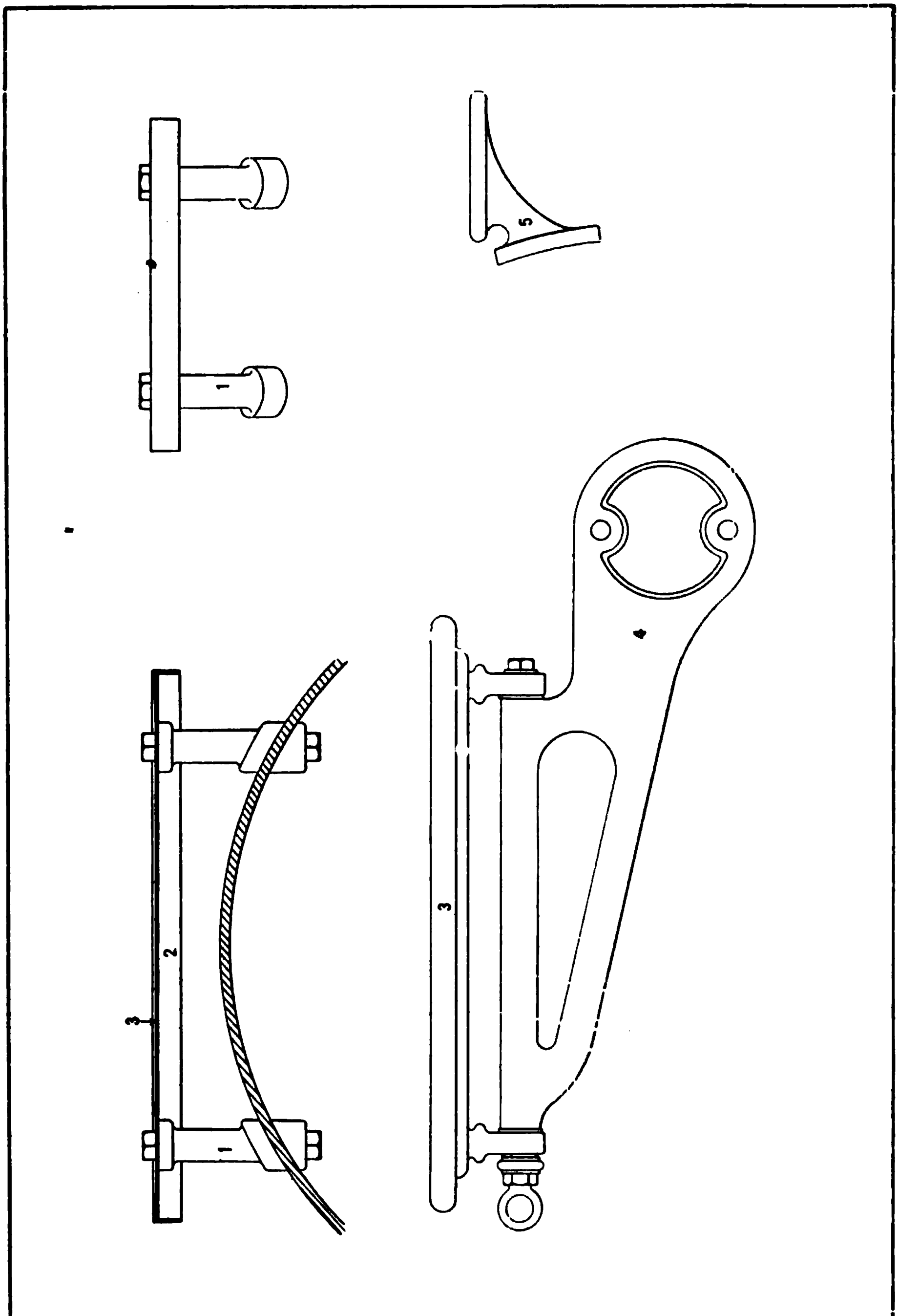


FEED WATER WORK.

Plate 51. EJECUTARON.

Ejecutases . . .	1.	Shaft.
Ejecutiva	2.	" Quadrant.
Ejecutivos . . .	3.	" Handle.
Ejecutoria . . .	4.	" Hanger.
Ejemplares . . .	5.	" Rod.
Ejeratio	6.	Cock Shaft.
Ejerceis	7.	" " Bearing.
Ejercer	8.	" Hanger.
Ejerceras	9.	Cock.
Ejercicios	10.	Pipe Clamp.

Plate 52.



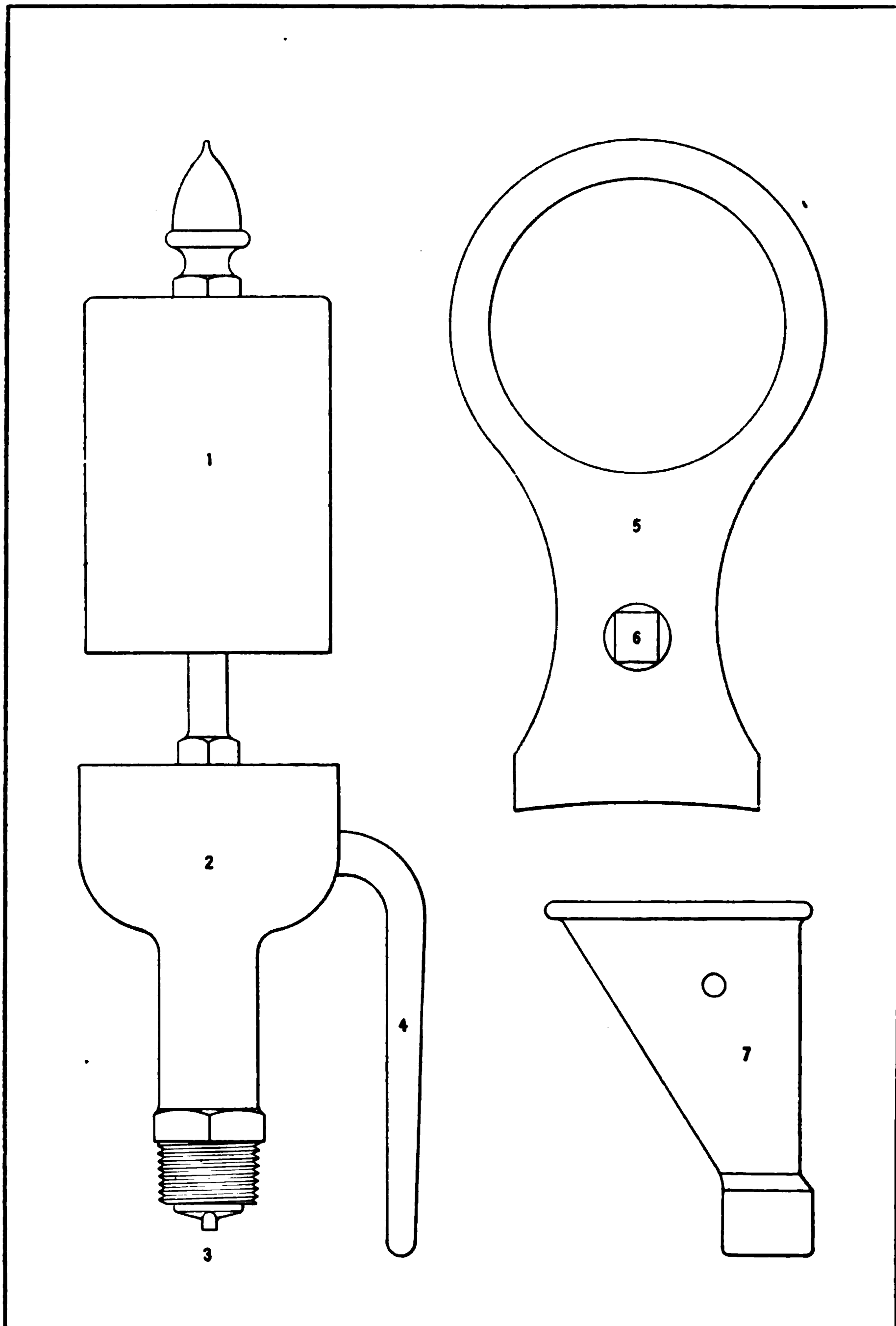
HEADLIGHT SHELVES AND SIGNAL LIGHT BRACKET.

Plate 52. EJERCIDOS.

Ejercieron	1.	Headlight Shelf Column.	
Ejerciteis	2.	" "	Edge.
Ejerzo	3.	"	Shelf.
Ejidos	4.	"	Bracket.
Ejointage	5.	Signal Light Bracket.	

Headlight brackets are made right and left, and orders for single brackets should specify the side.

Plate 53.

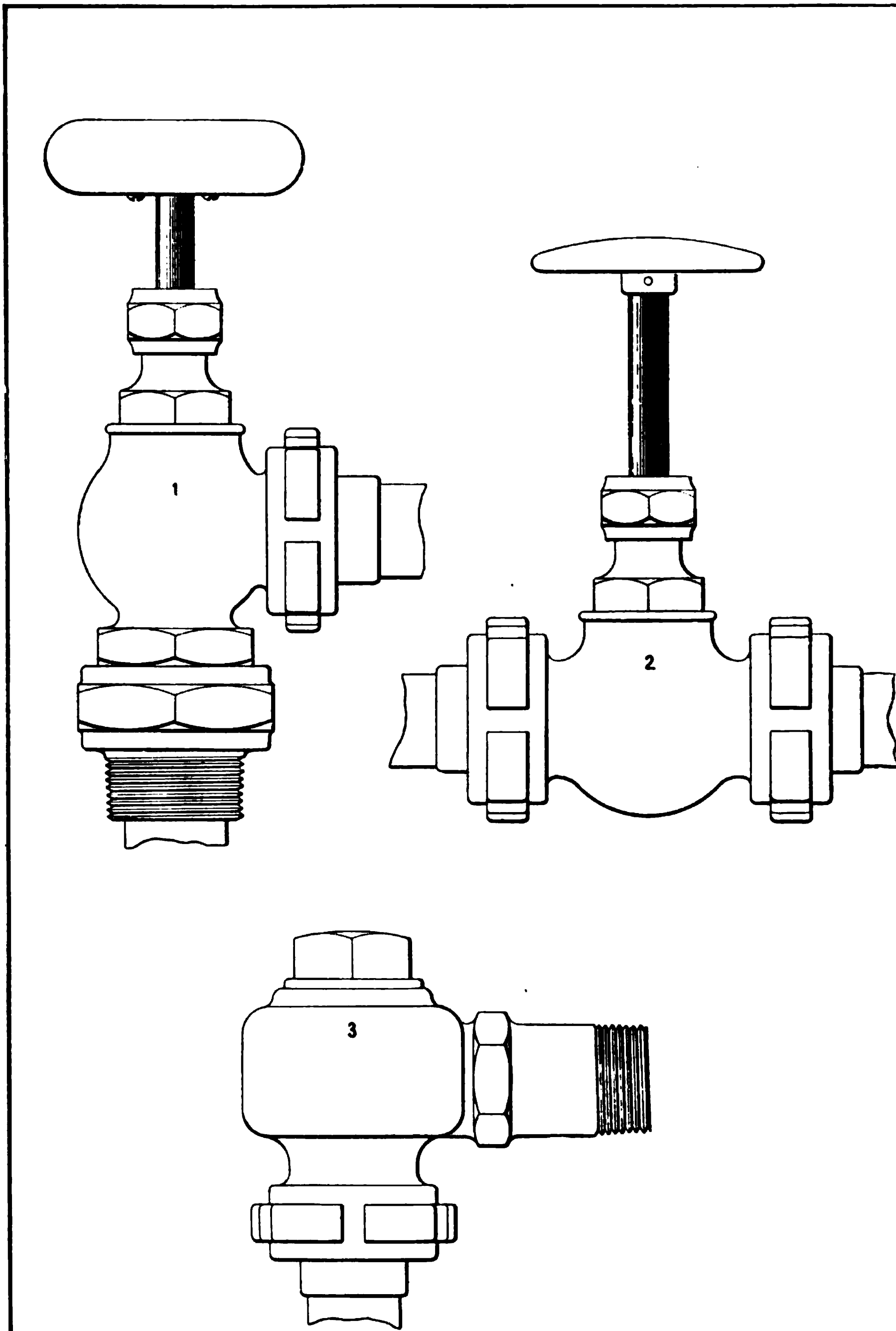


WHISTLE, STEAM GAUGE STAND AND DRIP FUNNEL.

Plate 53. EJOUIR.

Ejulabilis . . .	1. Whistle Bell.
Ejulabis	2. " Bowl.
Ejulabo	3. " Valve.
Ejulandi	4. " Lever.
Ejulandos . . .	5. Steam Gauge Stand.
Ejulandum . .	6. Cab Lamp "
Ejulas	7. Gauge Cock Drip Funnel.

Plate 54.



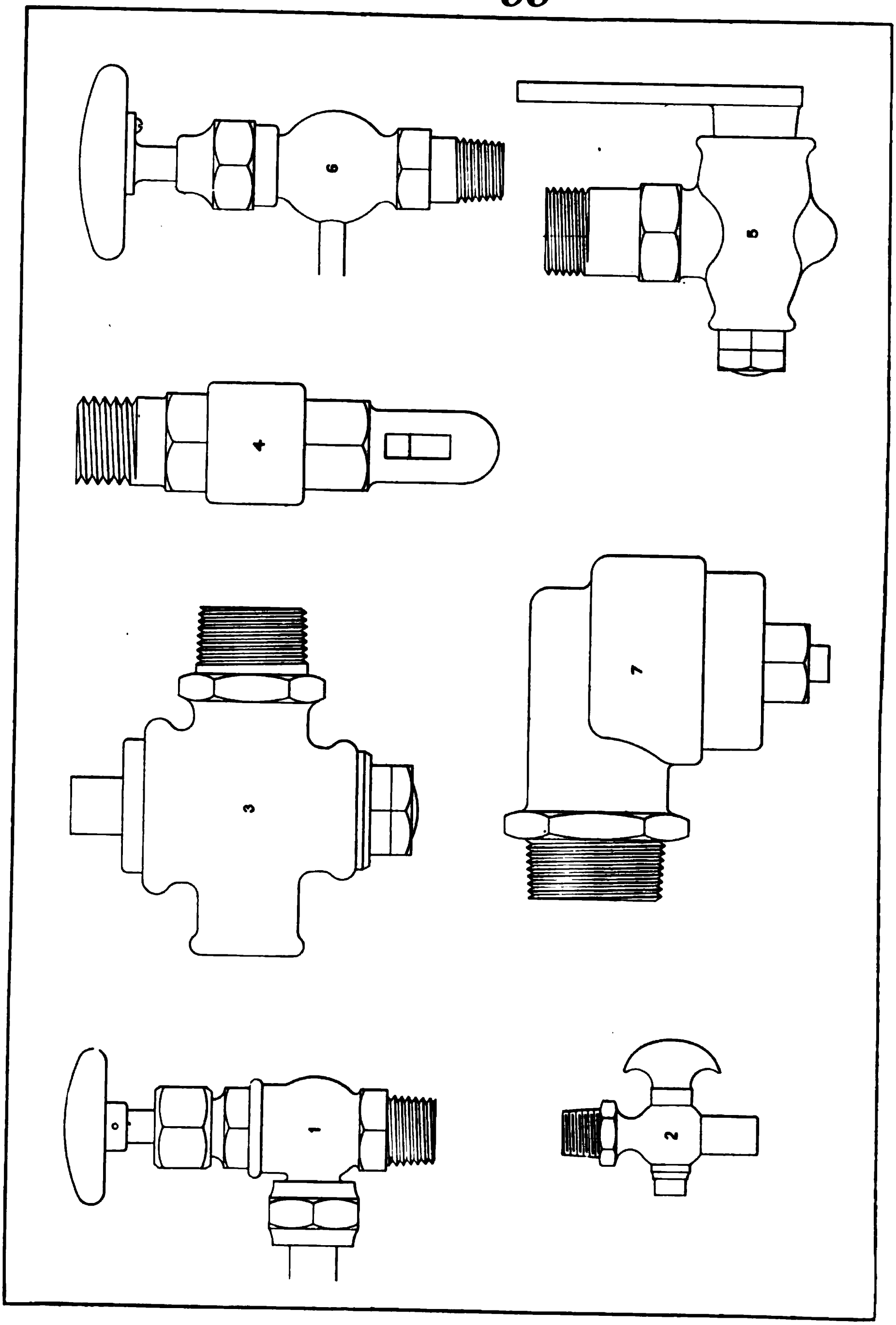
INJECTOR VALVES.

Plate 54. EJULATION.

Ejulatos	1. Steam Valve.
Ejulatuum	2. Feed "
Ejulavi	3. Check "

In ordering these parts, if they are required for any change from original dimensions, or additional to what was first put on the engine, the size and kind of pipes to be used should be specified.

Plate 55.



VALVES AND COCKS.

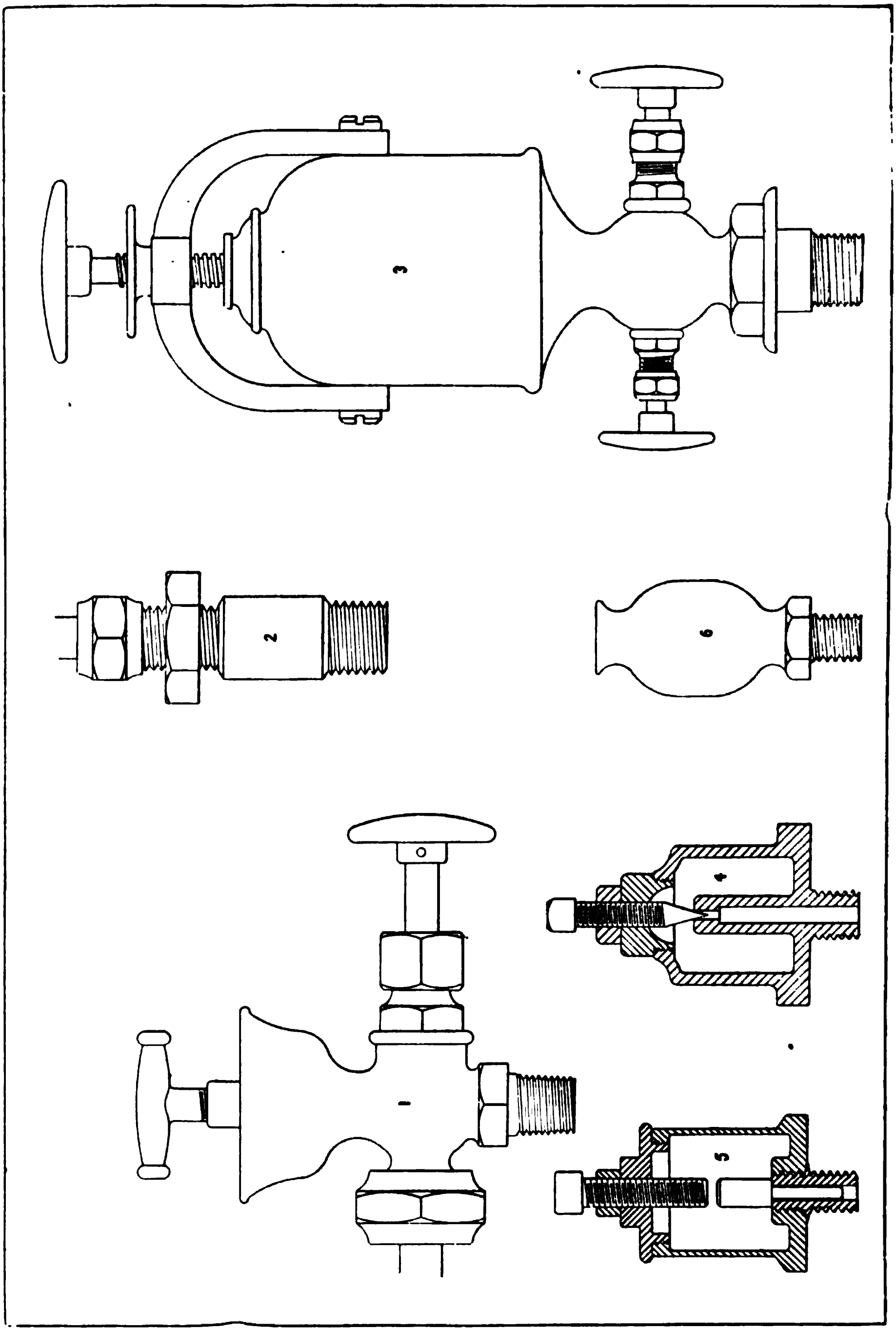
Plate 55. EJULAVISTI.

Ejulitabo	1.	Blower, Heater, Steam Brake Stop Valve or Spark Ejector Valve.
Ejulitamus	2.	Drip Cock.
Ejulitas	3.	Blow-off Cock.
Ejulito	4.	Cylinder Cock (Buchanan style).
Ejulo	5.	" Cock.
Ejuncesco	6.	Gauge "
Ejuncido	7.	Steam Chest Relief Valve.

In ordering cylinder cocks when not in full sets, the side they are wanted for must invariably be specified.

In ordering valves covered by number 1 above, specify the name of the valve wanted, as these valves are of different sizes, though of the same type.

Plate 56.



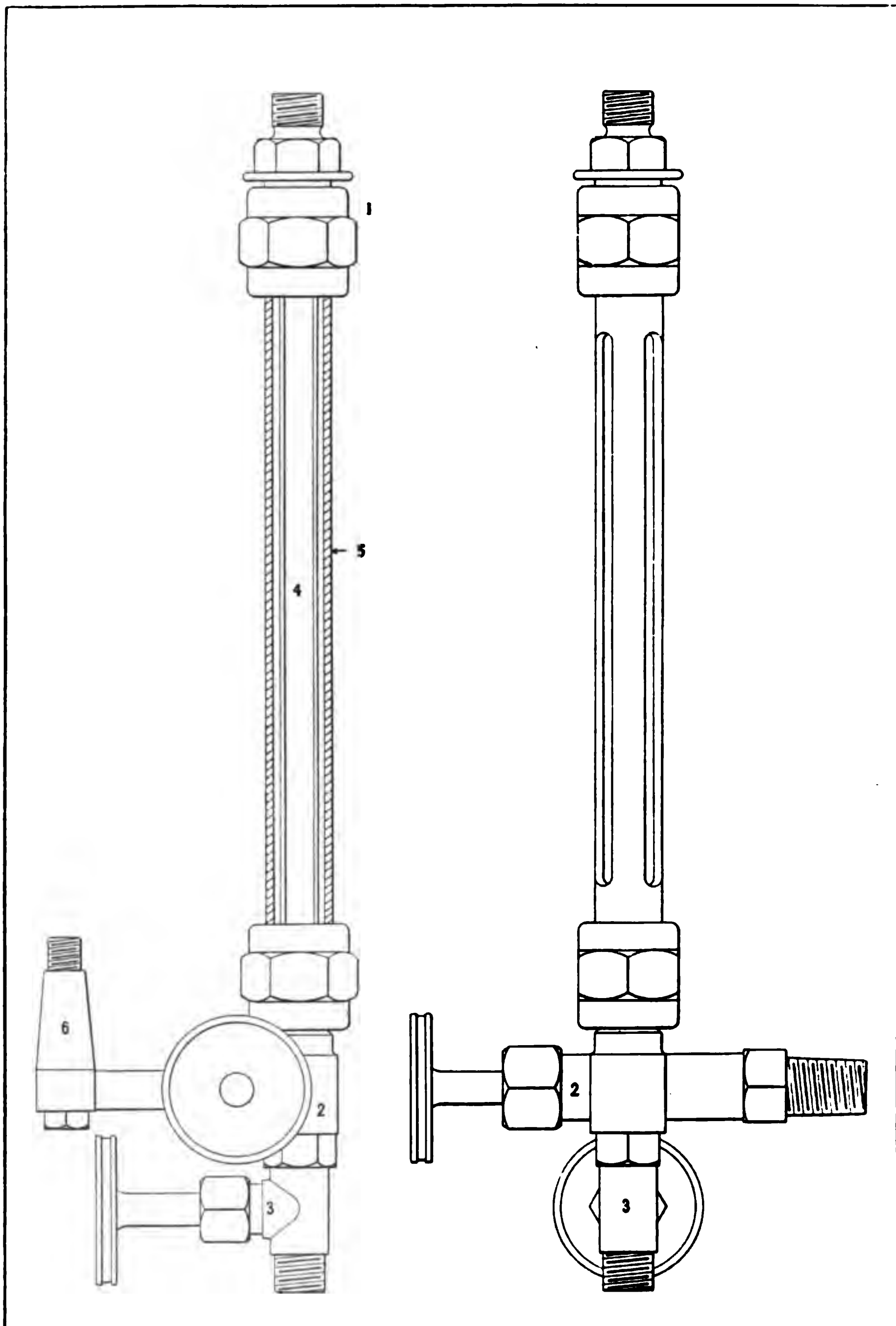
OIL CUPS.

Plate 56. EJUNCIDUS.

Ejusmodi	1. Cylinder Oiler in Cab, Baldwin style. (See Plates 77 and 78 for Sight Feed Cylinder Lubricators.)
Ekbatana	2. Oil Pipe Connection on Steam Chest.
Ekdemos	3. Condensing Oil Cup " " "
Ekelgeruch	4. Crosshead, Guide, or Connecting Rod Oil Cup (Needle style).
Ekellos	5. Crosshead, Guide, or Connecting Rod Oil Cup (Plunger style).
Ekevin	6. Rock Shaft Oil Cup.

In ordering numbers 4 or 5, it will be necessary to specify whether they are wanted for crossheads, guides, or rods.

Plate 57.



GLASS WATER GAUGE.

Plate 57. EKIAM.

Eklektus	1. Upper Fitting.
Ekloge	2. Lower "
Ekmannite . .	3. Drain Valve.
Eknomos . . .	4. Glass.
Ekrebel	5. Guard.
Ekron	6. Water Gauge Lamp Bracket.

Plate 58.

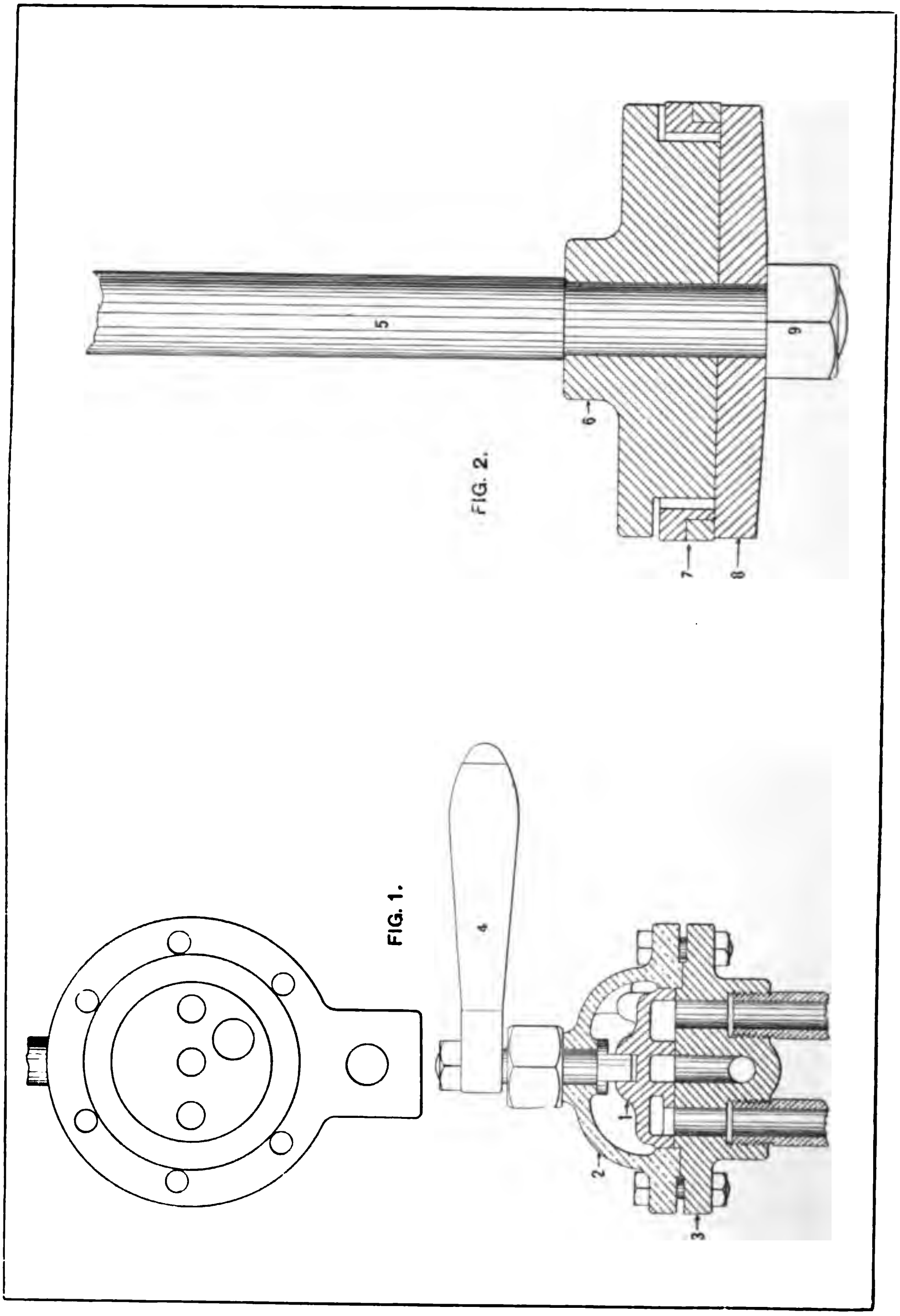


FIG. 1.

FIG. 2.

ENGINEER'S BRAKE VALVE AND STEAM BRAKE PISTON.

Plate 58. EKSTERN.

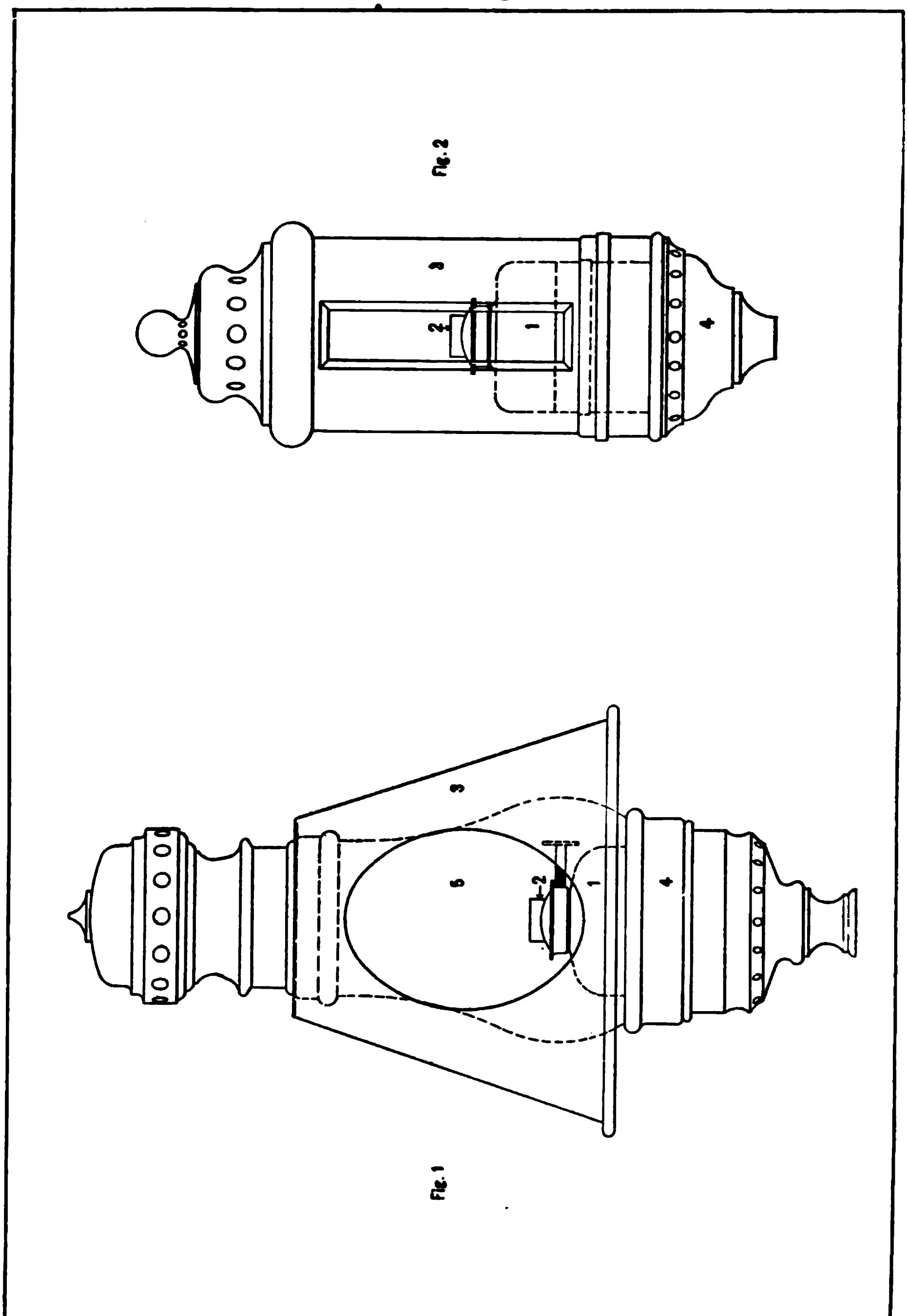
Eksternest . . . FIG. 1.—Engineer's Brake Valve. . . .

Eksteroog . . . 1. Disc Valve.
Elabitur. . . . . 2. Valve Cover.
Elabor. . . . . . 3. " Bcdy.
Elaborab . . . . 4. Handle.

Elaborablc . . . FIG. 2.—Steam Brake Piston.

Elaboracao . . . 5. Steam Brake Piston Rod.
Elaborados . . . 6. " " Piston.
Elaborammo . . 7. " " " Packing Rings.
Elaboraron . . . 8. " " " Follower.
Elaborassi . . . 9. " " " Nut.

Plate 59.



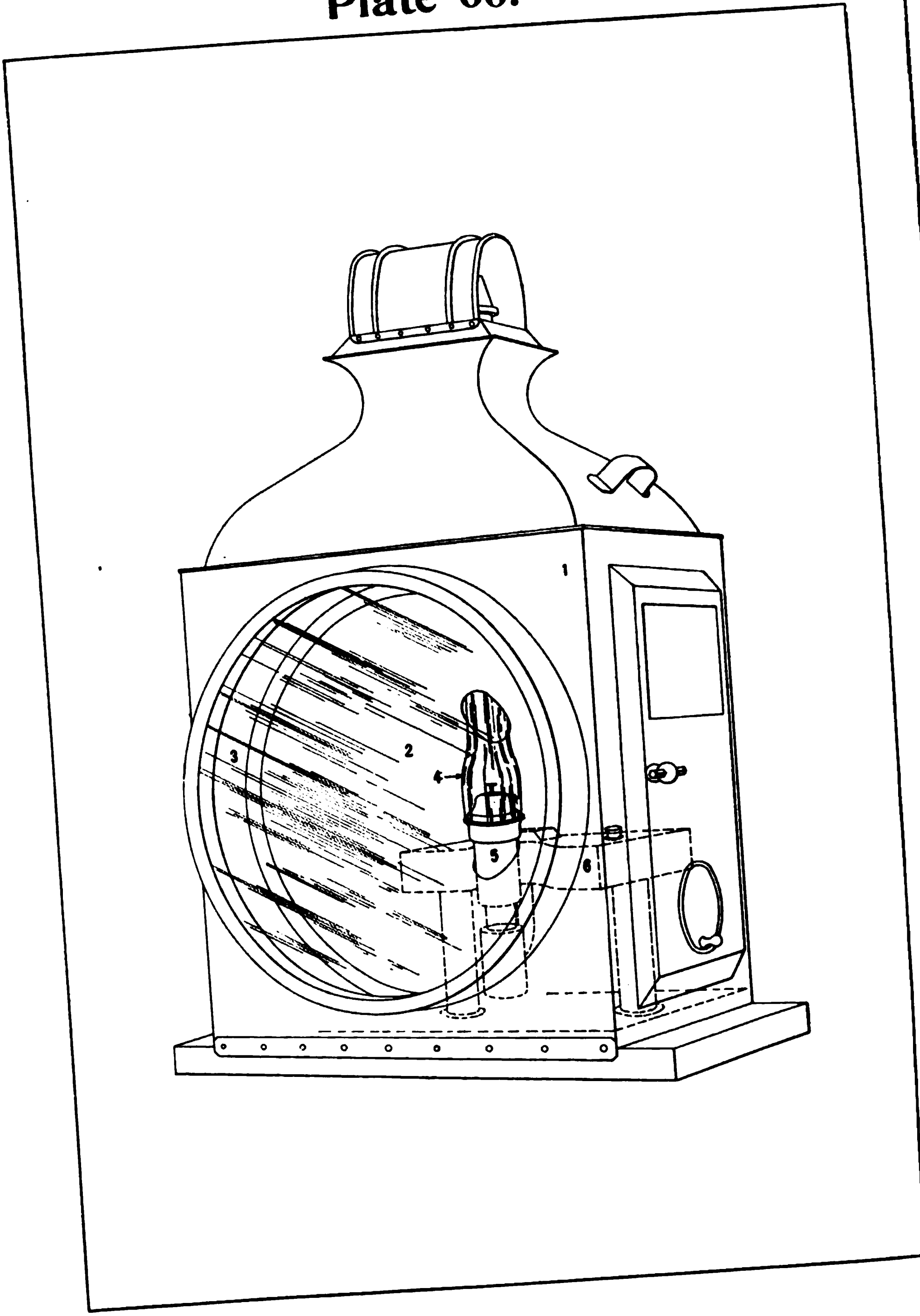
STEAM GAUGE LAMP AND WATER GAUGE LAMP.

Plate 59. ELABORATE.

Elaboratio . . . . . FIG. 1.—Steam Gauge Lamp.
Elaboratus . . . . FIG. 2.—Water " "

Elaborava . . . 1. Reservoir.
Elaborerai . . . 2. Burner.
Elacao . . . . . 3. Shade.
Elacatarum . . 4. Base.
Elacaties . . . . 5. Globe.

Plate 60.

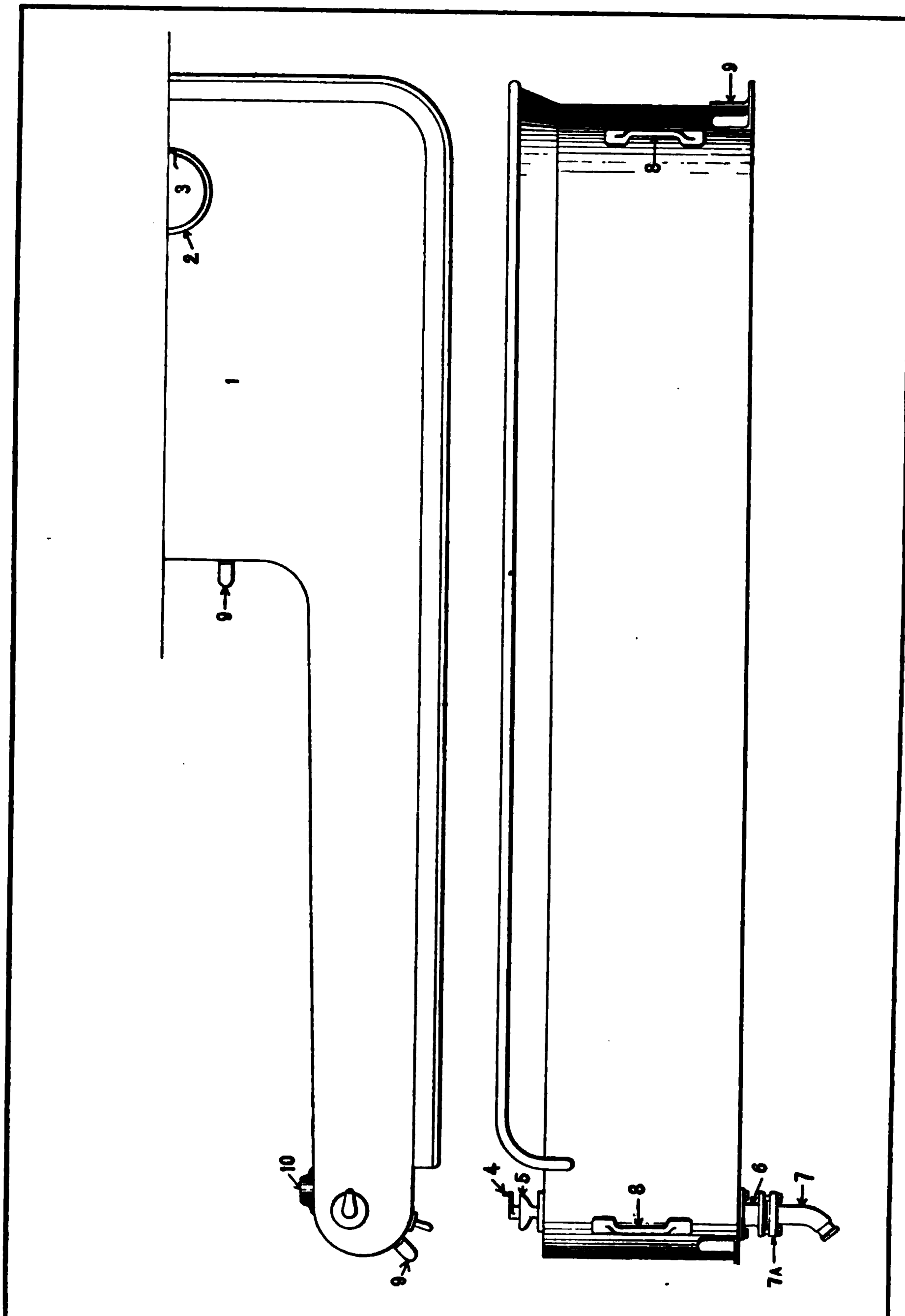


HEADLIGHT.

Plate 60. ELACHESTE.

Elachie	1. Case.
Elactesco . . .	2. Reflector.
Eladah	3. Glass.
Elaeodique . .	4. Chimney.
Elaeococca . .	5. Burner.
Elaeolithe . .	6. Reservoir.

Plate 61.

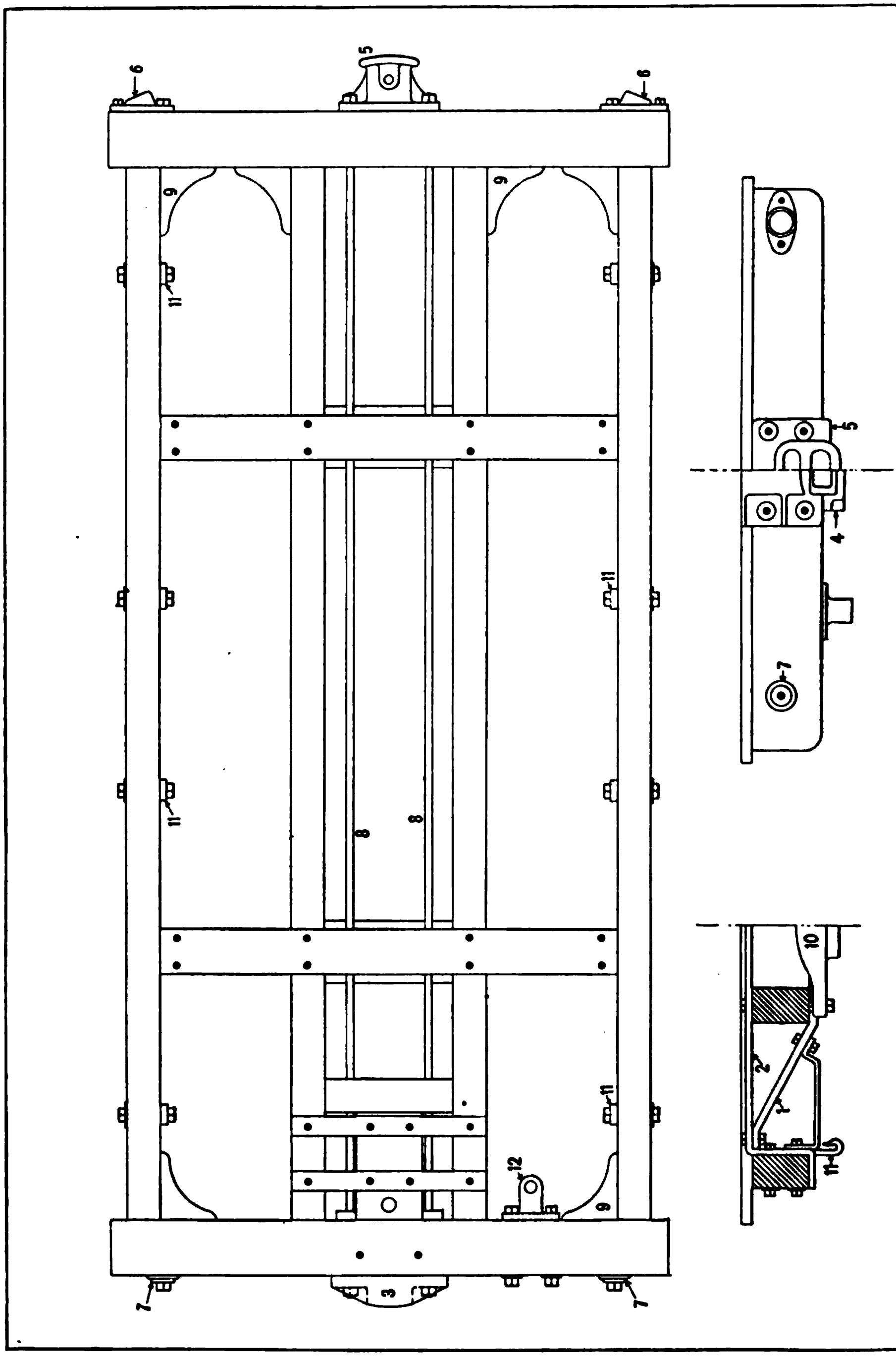


WATER TANK.

Plate 61. ELAEOMETRE.

Elaeon	1. Tank.
Elaeoptene	2. Filling Funnel.
Elaeothese	3. Funnel Lid.
Elaerine	4. Valve Lifter.
Elaeusa	5. " Wheel.
Elafabosco	6. " Body.
Elafro	7. " Gooseneck.
Elagabal	7A. " " Flange.
Elagabalus	8. Handles.
Elagage	9. Lugs.
Elaguer	10. Fuel Board Angle Iron.

Plate 62.



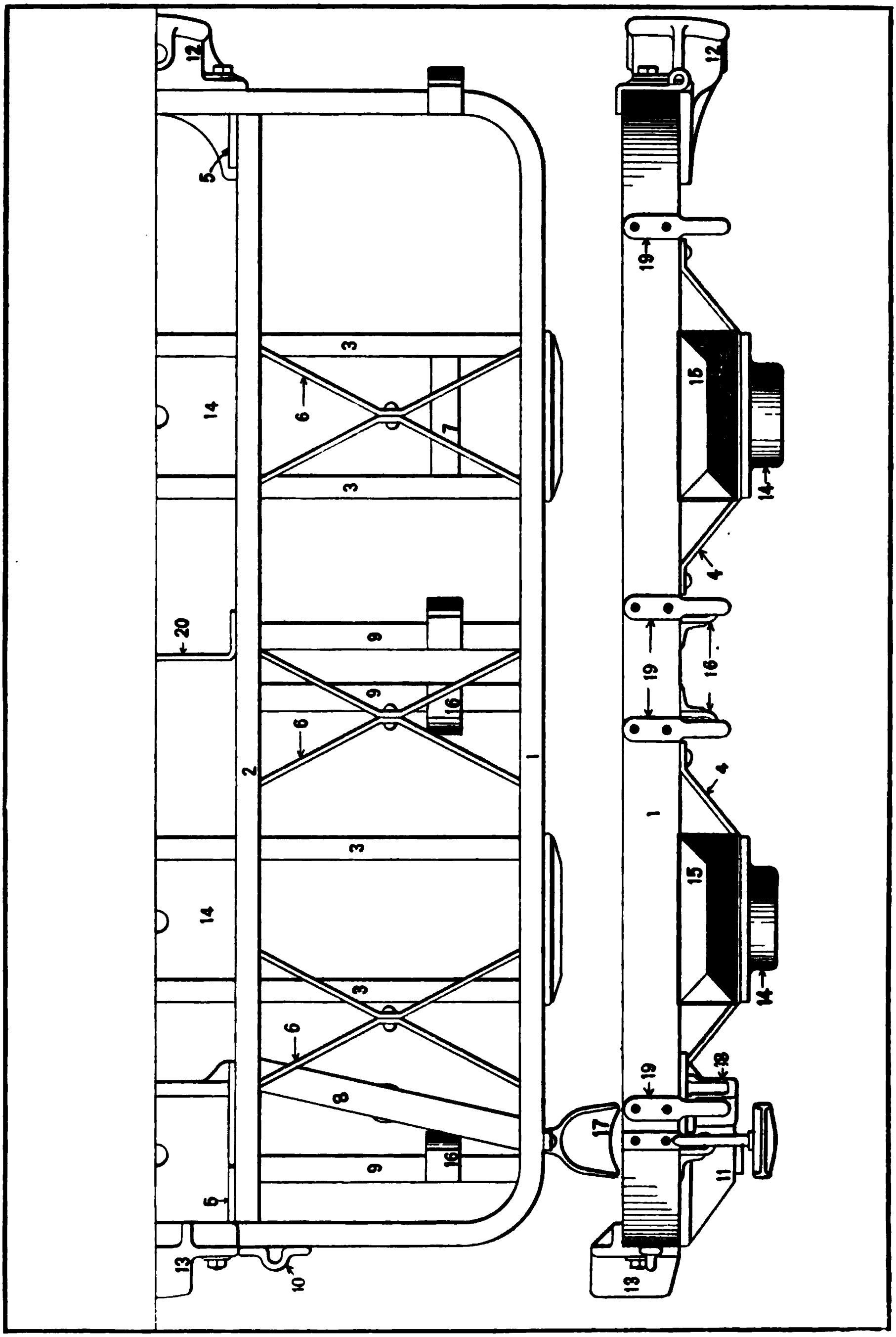
TENDER FRAME, WOOD.

Plate 62. ELAHIOUN.

Elaidate	1.	Truss Bar.
Elaidique	2.	" " Crosstie.
Elaiodic	3.	Wedge Block or Chafing Casting.
Elaiodo	4.	Front Draw Casting.
Elaiometer . . .	5.	Back " "
Elaique	6.	Pushing Shoe.
Elaise	7.	Frame Washer.
Elambis	8.	Longitudinal Draw Casting Bolt.
Elamene	9.	Corner Bracket.
Elancais	10.	Centre Pin.
Elancant	11.	Safety Chain Hook.
Elancerons . . .	12.	Brake Shaft Guide.

Orders for centre pins should specify whether front or back are required when not for full sets.

Plate 63.



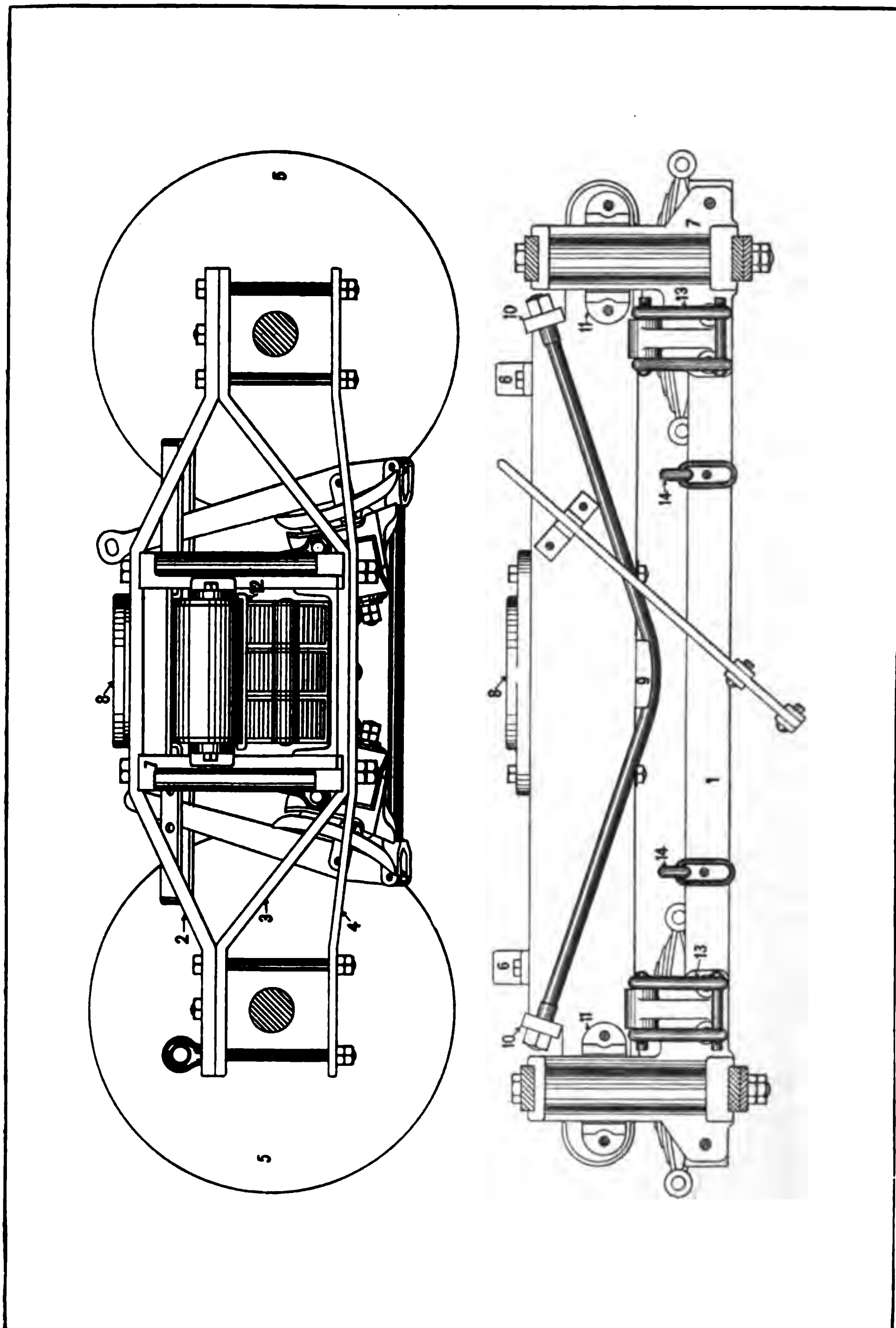
TENDER FRAME, IRON.

Plate 63. ELANCEUR.

Elancons	1.	Side Channel Bar.
Elanddier	2.	Longitudinal Channel Bar.
Elangide	3.	Transverse " "
Elanguesco . . .	4.	" " " Strap.
Elangueur . . .	5.	Corner Plate.
Elanion	6.	Brace.
Elaolite	7.	Side Bearing.
Elaopten	8.	Brake Shaft Crosstie.
Elaphidion . . .	9.	" Hanger Angle Iron.
Elaphinis	10.	Safety Chain Hanger.
Elaphocere . . .	11.	Front Draw Casting.
Elaphoide	12.	Back " "
Elaphomyce . .	13.	Chafing Casting.
Elaphopsis . . .	14.	Centre Pin.
Elaphro	15.	Bolster Cap.
Elaphrope	16.	Brake Clevis.
Elapidae	17.	Tender Step.
Elapidatus . . .	18.	Brake Shaft Step.
Elapoidite	19.	Safety Chain Hook.
Elapsion	20.	Brace.

In ordering centre pins, observe the instructions for Plate 62.

Plate 64.



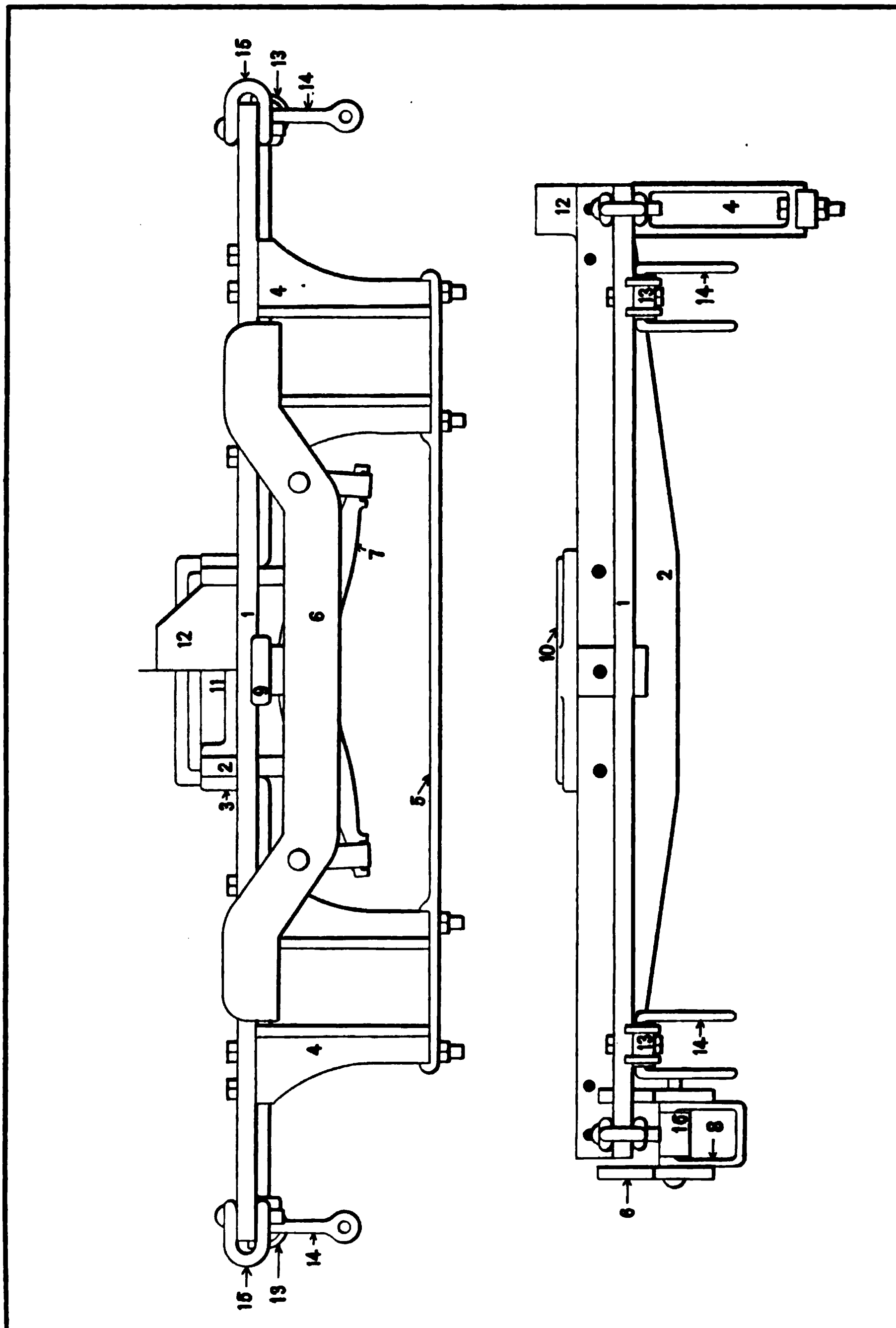
TENDER TRUCK, WOOD.

Plate 64. ELAQUEATOS.

Elaqueatum . . .	1. Channel Bar.
Elargendo	2. Top Bar of Frame.
Elargiamo	3. Truss " " "
Elargimes	4. Bottom " " "
Elargior	5. Wheel.
Elargiront	6. Side Bearing.
Elargisco	7. Frame Filling Piece.
Elargissi	8. Centre Plate.
Elargita	9. Truss "
Elargitus	10. " Washer.
Elargivate	11. Bolster Guide.
Elasme	12. Spring Seat.
Elasmia	13. Brake Clevis.
Elasmodon	14. " Beam Safety Chain.

In ordering parts for a single truck, the order should specify whether they are wanted for front or back truck.

Plate 65.



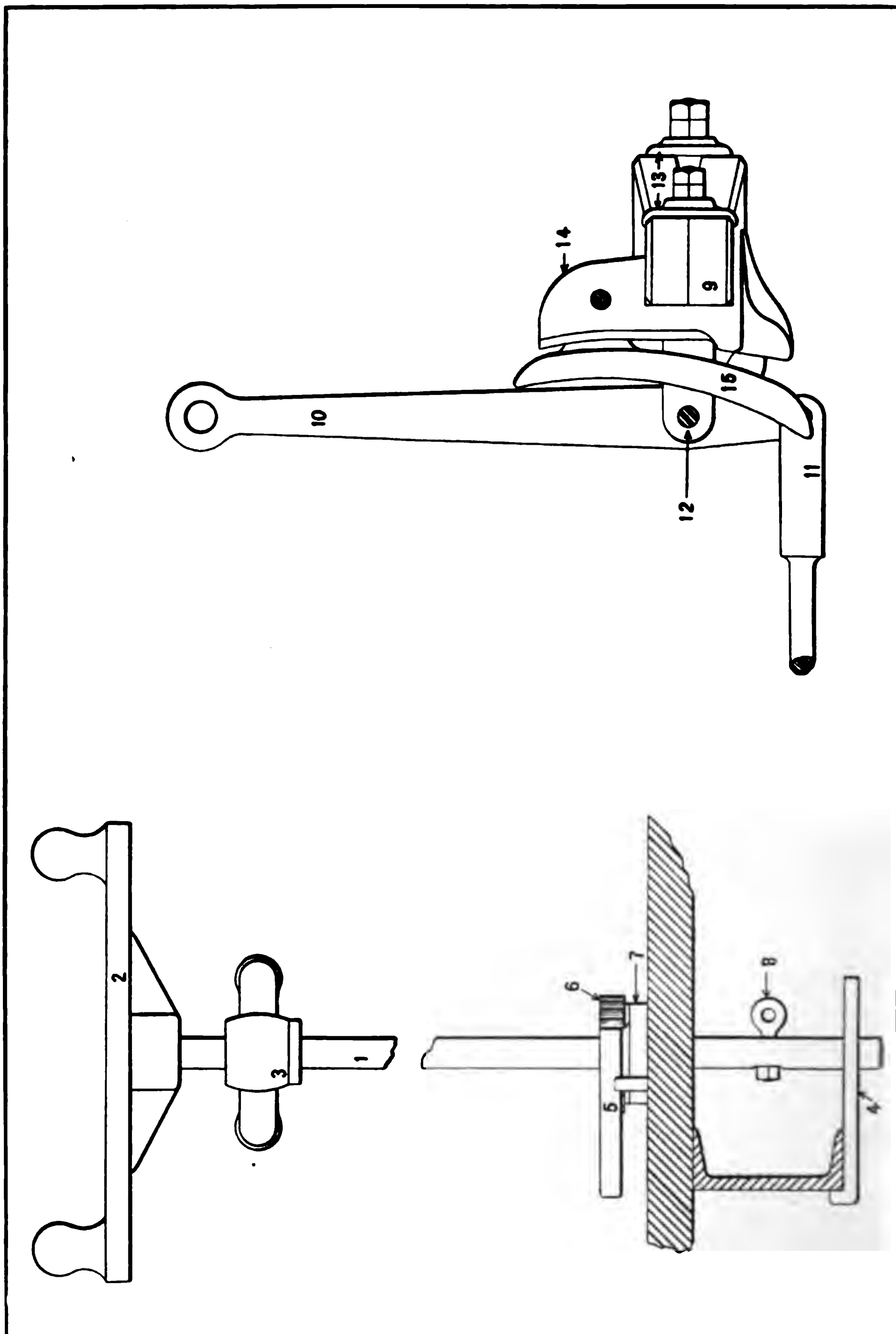
TENDER TRUCK, WROUGHT IRON.

Plate 65. ELASMOSE.

Elassesco	1.	Frame.
Elassonyx. . . .	2.	Crosstie.
Elasterio	3.	" Brace.
Elastical.	4.	Pedestal.
Elasticity	5.	" Cap.
Elasticos	6.	Equalizing Beam.
Elastique	7.	Spring.
Elatche	8.	" Link.
Elatedly	9.	" Seat.
Elatedness . . .	10.	Centre Plate.
Elateius	11.	Frame Filling Piece.
Elateridae . . .	12.	Side Bearing.
Elaterion	13.	Brake Hanger.
Elaterium	14.	" Clevis.
Elatine	15.	Safety Chain Clevis.
Elationis.	16.	Spring Link Washer.

In ordering parts for a single truck, observe the instructions for Plate 64.

Plate 66.

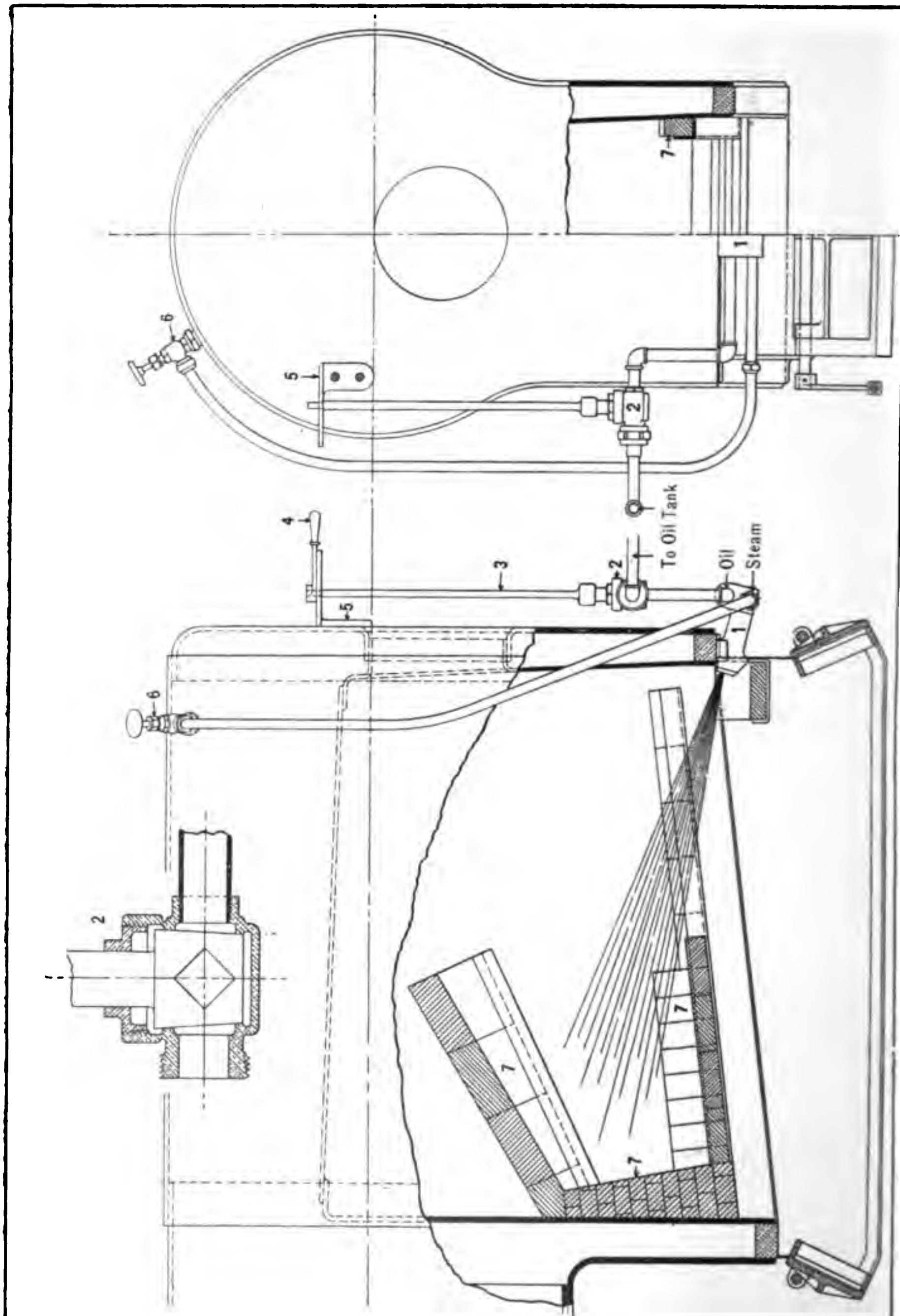


TENDER BRAKE WORK.

Plate 66. ELATOSTEMA.

Elatrabis . . .	1. Shaft.
Elatrabo	2. Handle.
Elatramus . . .	3. Hanger.
Elatrarem . . .	4. Step.
Elatras	5. Pawl.
Elautum	6. Ratchet.
Elavavi	7. Plate.
Elavavisti . . .	8. Eye Bolt.
Elaveuse . . .	9. Beam.
Elavo	10. Lever.
Elbae	11. " Rod.
Elberich	12. " Jaw.
Elbeuvien . . .	13. Washer.
Elbidorum . .	14. Head.
Elbidus	15. Shoe.

Plate 67.

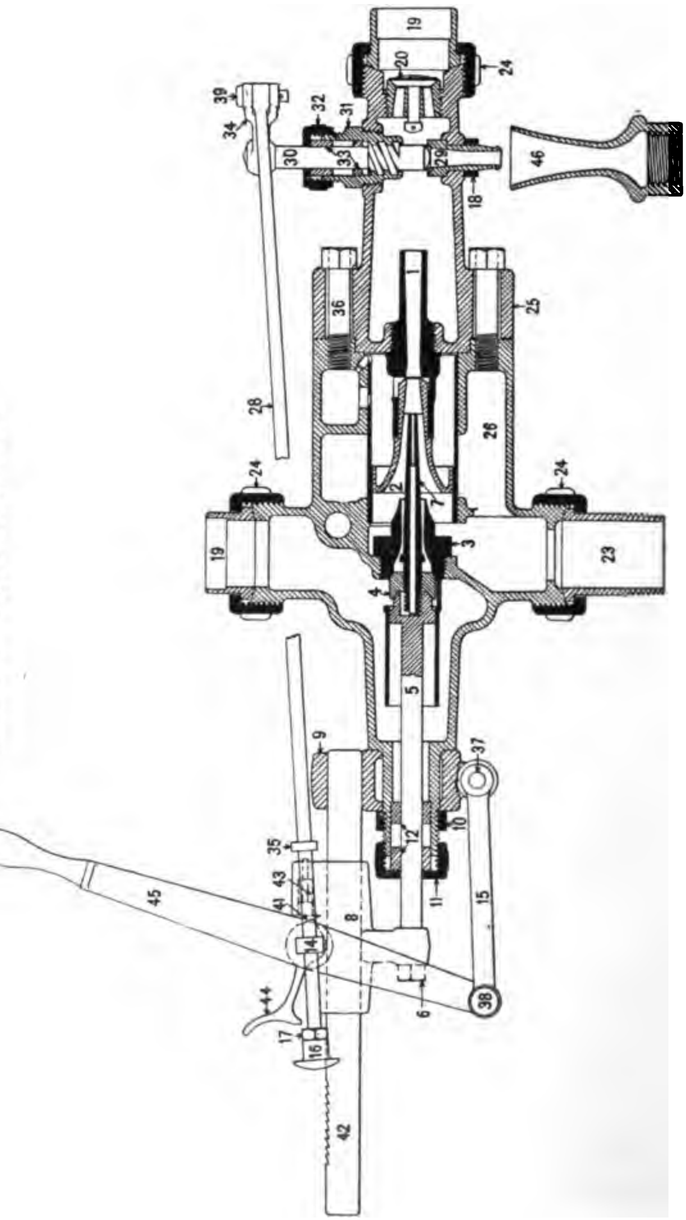


APPARATUS FOR BURNING FUEL OIL.

Plate 67. ELBKAHN.

Elblachs	1.	Oil Injector.
Elbnachen . . .	2.	" Cock.
Elborum	3.	" " Shaft.
Elbow	4.	" " " Handle.
Elbowed	5.	" " Quadrant.
Elbowing . . .	6.	" Injector Steam Valve.
Elcaja	7.	Fire Brick.

Plate 68.



SELLERS INJECTOR, 1876.

SELLERS INJECTOR, 1876.

Plate 68. ELCATE.

Elcathorax . . .	1. Delivery Tube.
Elcesaite	2. Combining Tube.
Elciaro	3. Steam Nozzle.
Elcidrio	4. Valve on No. 7.
Elcisma	5. Solid Spindle.
Elcoma	6. Nut on Top of No. 5.
Elderitz	7. Hollow Spindle.
Elderly	8. Crosshead.
Elders	9. Collar on No. 26.
Eldership	10. Lock Nut for No. 9.
Elderwort	11. Follower on No. 26.
Eldest	12. Packing Rings under No. 11.
Eldorado	14. Fulcrum Pin.
Eleagno	15. Link.
Eleanthe	16. Knob on end of No. 28.
Eleasah	17. Lock Nut for No. 16.
Eleates	18. Nut on No. 29.
Eleatico	19. Plain Ring for Copper Pipe.
Eleaticus	20. Check Valve.

(Continued on page 388)

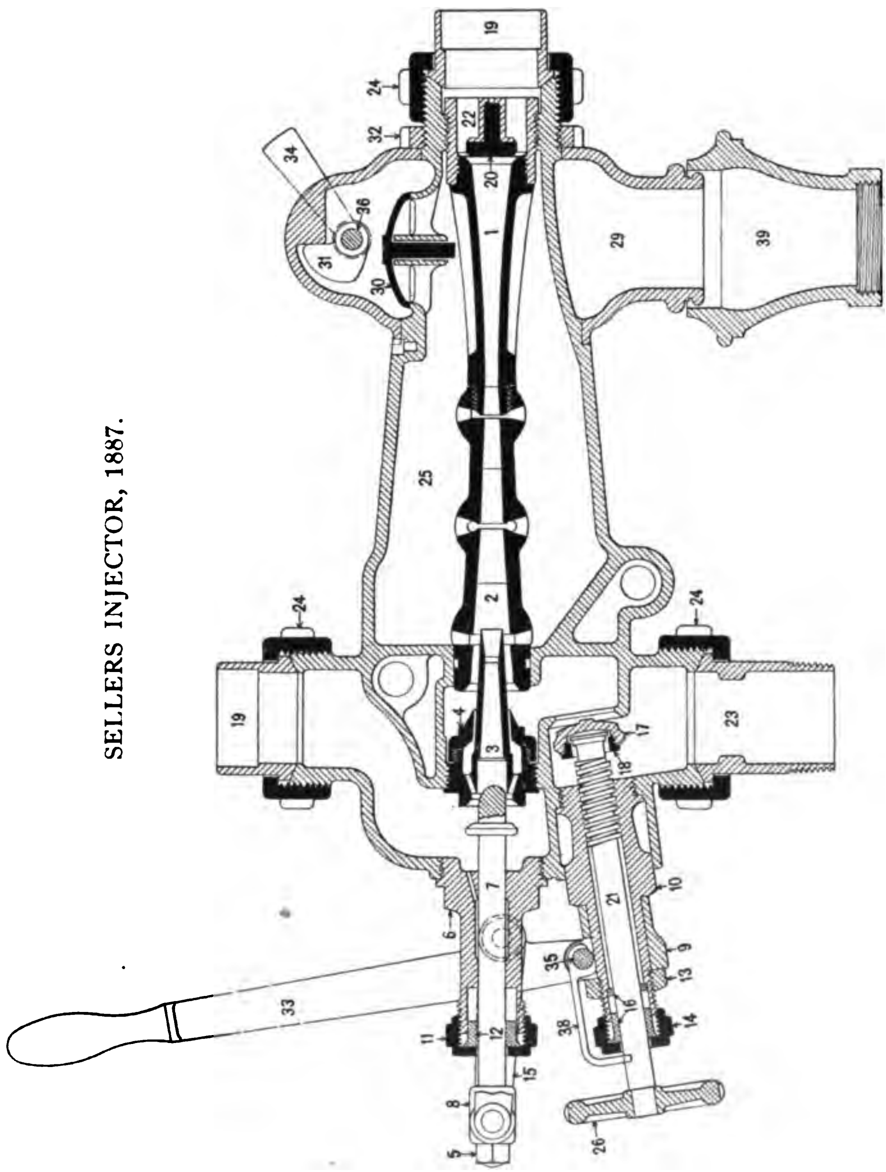
Plate 68, continued.

See page 386.

Eleatique	23.	Union to Pipes.
Eleatisme	24.	Coupling Nut.
Eleazurus. . . .	25.	Lower Cylinder.
Elecampe	26.	Upper "
Eleccion	28.	Connecting Rod.
Elecciones . . .	29.	Waste Pipe.
Elecebra.	30.	Screw Valve.
Elecebris	31.	Stuffing Box for No. 30.
Electamus . . .	32.	Follower on No. 31.
Electarium . . .	33.	Packing Rings under No. 32.
Electeur.	34.	Lever on No. 30.
Electicism . . .	35.	Collar on No. 28.
Electilis	36.	Stud Bolts.
Electively	37.	Pin through Nos. 9 and 15.
Electivite	38.	" " " 15 " 45.
Electorat	39.	" " " 28 " 34.
Electoress . . .	41.	Pressure Foot.
Electrical	42.	Guide Rod.
Electricos	43.	Spring for No. 41.
Electrify	44.	Latch.
Electrique. . . .	45.	Starting Lever.
Electrisch	46.	Funnel for Overflow.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages 213 to 221.

Plate 69.



SELLERS INJECTOR, 1887.

For description of plate, see pages 390 and 391.

SELLERS INJECTOR, 1887.

Plate 69. ELECTRISE.

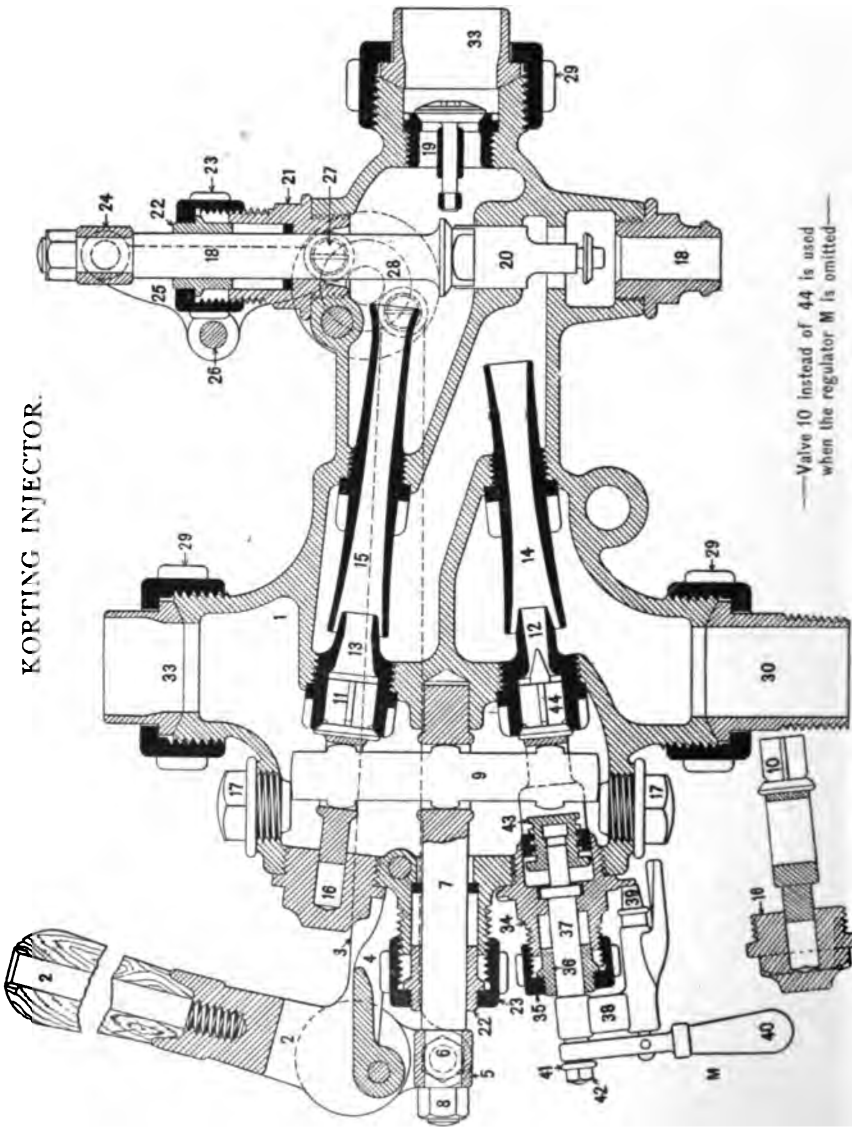
See page 389.

Electrode	1.	Delivery Tube.
Electrum	2.	Combining Tube.
Electuaire. . . .	3.	Forcing Steam Nozzle.
Electuary	4.	Lifting " "
Eleemosyna. . .	5.	Spindle Nut.
Eleescier	6.	Stuffing Box for Spindle.
Elefanta	7.	Spindle.
Elefantes	8.	Crosshead.
Elefantino . . .	9.	Collar on No. 10.
Elefas	10.	Stuffing Box for Water Valve.
Elegamment . .	11.	Follower for No. 6.
Elegance	12.	Packing Ring in No. 6.
Elegancias . . .	13.	Lock Nut for No. 9.
Elegantiae . . .	14.	Follower for No. 10.
Elegantly	15.	Links.
Elegaverim . . .	16.	Packing Ring in No. 10.
Elegavisti	17.	Water Valve.
Elegeion	18.	Ring in No. 17.
Elegendo	19.	Plain Rings for Copper Pipe.
Eleggerei	20.	Check Valve.

Eleggerla	21.	Valve Stem for No. 17.
Eleggevano	22.	Guide for No. 20.
Eleggono	23.	Plain Unions for Iron Pipes.
Elegiacal	24.	Coupling Nuts.
Elegiambic	25.	Injector Body.
Elegiaque	26.	Hand Wheel on No. 21.
Elegiast	29.	Waste Pipe.
Elegibles	30.	Waste Valve.
Elegidas	31.	Cam for closing Waste Valve.
Elegidion	32.	Jam Nut for No. 29.
Elegidores	33.	Starting Lever.
Elegimos	34.	Lever on Cam Shaft.
Elegir	35.	Pin through No. 9 and No. 33.
Elegiremos	36.	Cam Shaft.
Elegisch	38.	Index.
Elegiuzza	39.	Funnel for Overflow.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages 213 to 221.

Plate 70.



KORTING INJECTOR.

KORTING INJECTOR.

Plate 70. ELEGIVEL.

Elegize	1.	Body.
Elegizing. . . .	2.	Hand Lever Complete.
Elegorum . . .	3.	Side Rods, Right and Left.
Eleicao	4.	Connecting Link and Pins.
Eleidis	5.	Crosshead for Starting Shaft.
Eleiotide	6.	Nuts for Crosshead.
Eleison	7.	Starting Shaft.
Eleito	8.	Nuts for Starting and Overflow Shafts.
Eleitorado . . .	9.	Yoke Bar.
Eleituario . . .	10.	Lower Steam Valve.
Elektoral	11.	Upper " "
Elektra	12.	Lower " Nozzle.
Eleleide.	13.	Upper " "
Elementado . .	14.	Lower Water "
Elementary . .	15.	Upper " "
Elementen . . .	16.	" Front Body Cap. (Also Lower.)
Elementos . . .	17.	Top and Bottom Body Caps.
Elementum . .	18.	Overflow Nozzle.
Elemieira. . . .	19.	Check Valve Complete.
Elemifere. . . .	20.	Overflow Valve Complete.

(Continued on page 394.)

Plate 70, continued.

See page 392.

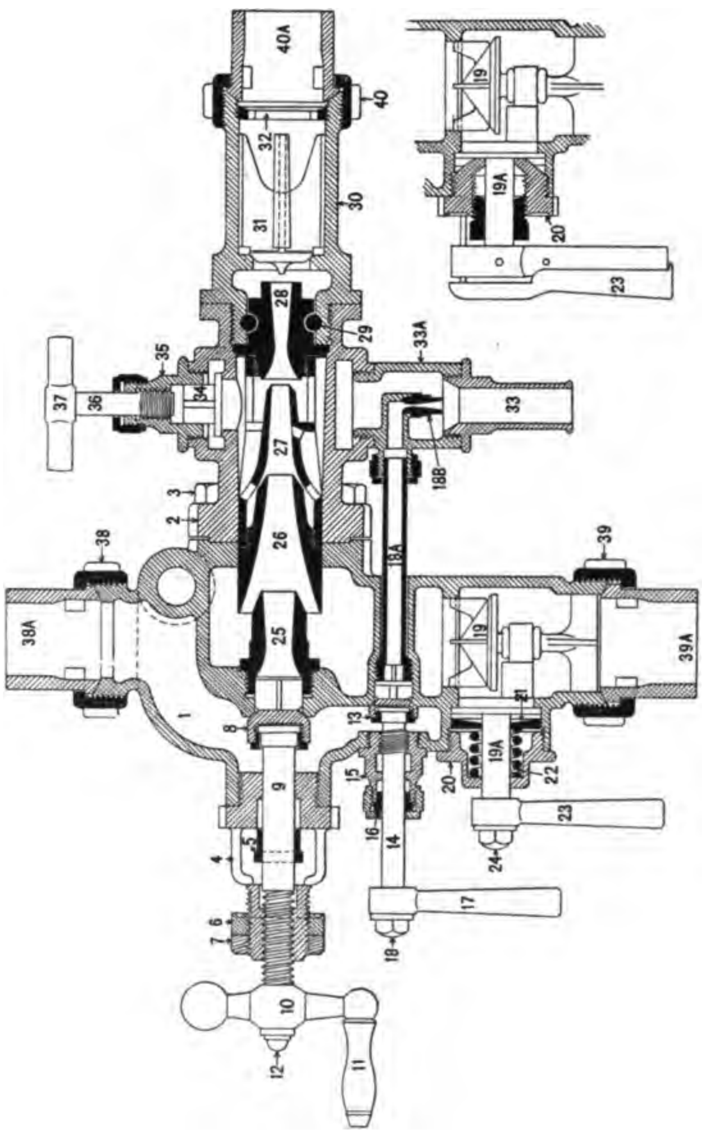
Elemina . . . 21. Overflow Stuffing Box.
Elemisalbe . . 22. Followers for Stuffing Boxes.
Elemosina . . 23. Nuts for Stuffing Boxes.
Elemporia . . 24. Crosshead for Overflow Valve.
Elenchical . . 25. Connecting Links for Overflow Valve.
Elenchie . . . 26. Pin for Connecting Links for Overflow Valve.
Elenchorum . 27. Screws " " " " "
Elenchos . . . 28. Bell Cranks for Overflow Valve.
Elenctici . . . 29. Coupling Nuts.
Elencticus . . 30. Unions for Iron Pipe.
Elenctique . . 31. Spanner Wrench.
Elend . . . . . 33. Unions for Copper Pipe.
Elendbalg . . 34. Throttle Valve Stuffing Box.
Elender . . . . 35. Nut for Stuffing Box.
Elendesten . . 36. Follower for Stuffing Box.
Elendmeer . . 37. Spindle for Throttle Valve.
Elendrecht . . 38. Arm for Latch on Throttle Valve.
Elendshof . . 39. Latch.
Elendsring . . 40. Handle.
Elenhirsch . . 41. Washer.
Elenthier . . . 42. Nut.
Eleocarpe . . 43. Adjusting Screw.
Eleocharis . . 44. Throttle Valve.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages 213 to 221.

If injectors do not have the regulator M, the parts including Nos. 34 to 44 are not wanted, and plain valve and cap substituted. Cap No. 16. Lower Steam Valve No. 10.

Plate 71.

MONITOR INJECTOR.



For description of plate, see pages 396 and 397

MONITOR INJECTOR.

Plate 71. ELEODENDRE.

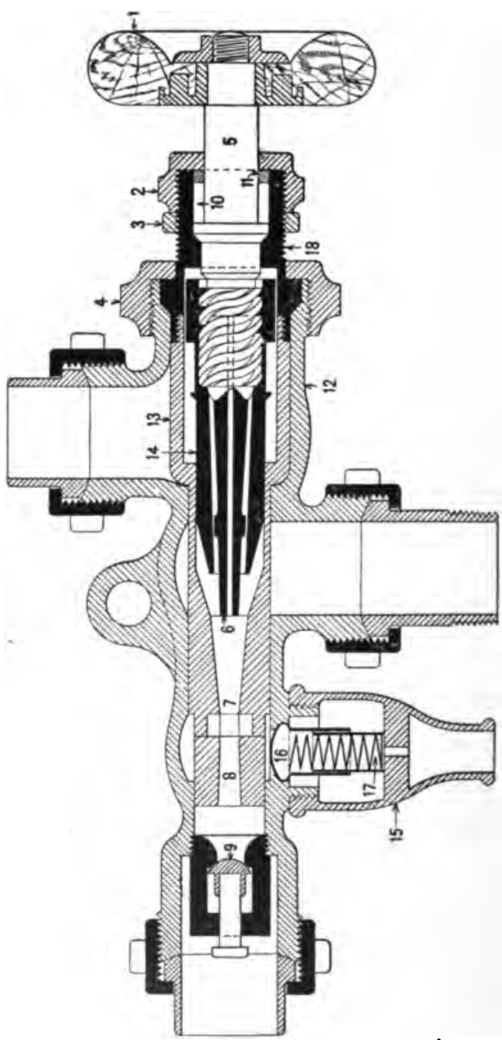
See page 395.

Eleodon . . .	1.	Body (back part).
Eleogari	2.	" (front part).
Eleogarum .	3.	" Screw.
Eleogoma . .	4.	Yoke.
Eleolate . . .	5.	" Gland.
Eleolique . .	6.	" Packing Nut.
Eleolithe. . .	7.	" Lock Nut.
Eleomeli. . .	8.	Steam Valve Disc and Nut.
Eleoneme . .	9.	" " Spindle.
Eleonore. . .	10.	" " Handle.
Eleontum . .	11.	" " Rubber Handle.
Eleophage. .	12.	" " Top Nut.
Eleopoli . . .	13.	Jet Valve Disc and Nut.
Eleosponde .	14.	" " Spindle.
Eleotesio . .	15.	" " Bonnet and Nut.
Eleothese . .	16.	" " Gland.
Eleozoma . .	17.	" " Lever Handle.
Eleozomus .	18.	" " Top Nut.
Elephancia .	18A.	" Tube.
Elephant. . .	18B.	Lifting Nozzle.

Elephantin	19.	Water Valve.
Elephenor	19A.	Eccentric Spindle.
Elephoro.	20.	Water Valve Bonnet.
Elesbao	21.	" " Packing Ring.
Elesmatis	22.	" " Spring.
Elesyces	23.	" " Lever Handle.
Elettari	24.	" " Top Nut.
Elettivo	25.	Steam Nozzle.
Elettorale	26.	Intermediate Nozzle.
Elettorato	27.	Condensing "
Elettore	28.	Delivery "
Elettriche	29.	Swivel Pins.
Elettrico	30.	Line Check.
Eleuchadio	31.	" " Valve.
Eleulaleus	32.	Stop Ring.
Eleusinian	33.	Overflow Nozzle.
Eleusinius	33A.	" Chamber with Nut.
Eleusippo	34.	Heater Cock Check.
Eleusis	35.	" " Bonnet and Nut.
Eleuthere	36.	" " Spindle.
Eleutheria	37.	" " T Handle.
Eleutherus.	38.	Coupling Nut, Steam End.
Eleutho	38A.	Tail Piece, " "
Elevabamos	39.	Coupling Nut, Water End.
Elevacion	39A.	Tail Piece, " "
Elevada	40.	Coupling Nut, Delivery End.
Elevadico	40A.	Tail Piece, " "

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages 213 to 221.

Plate 72.



ECLIPSE INJECTOR.

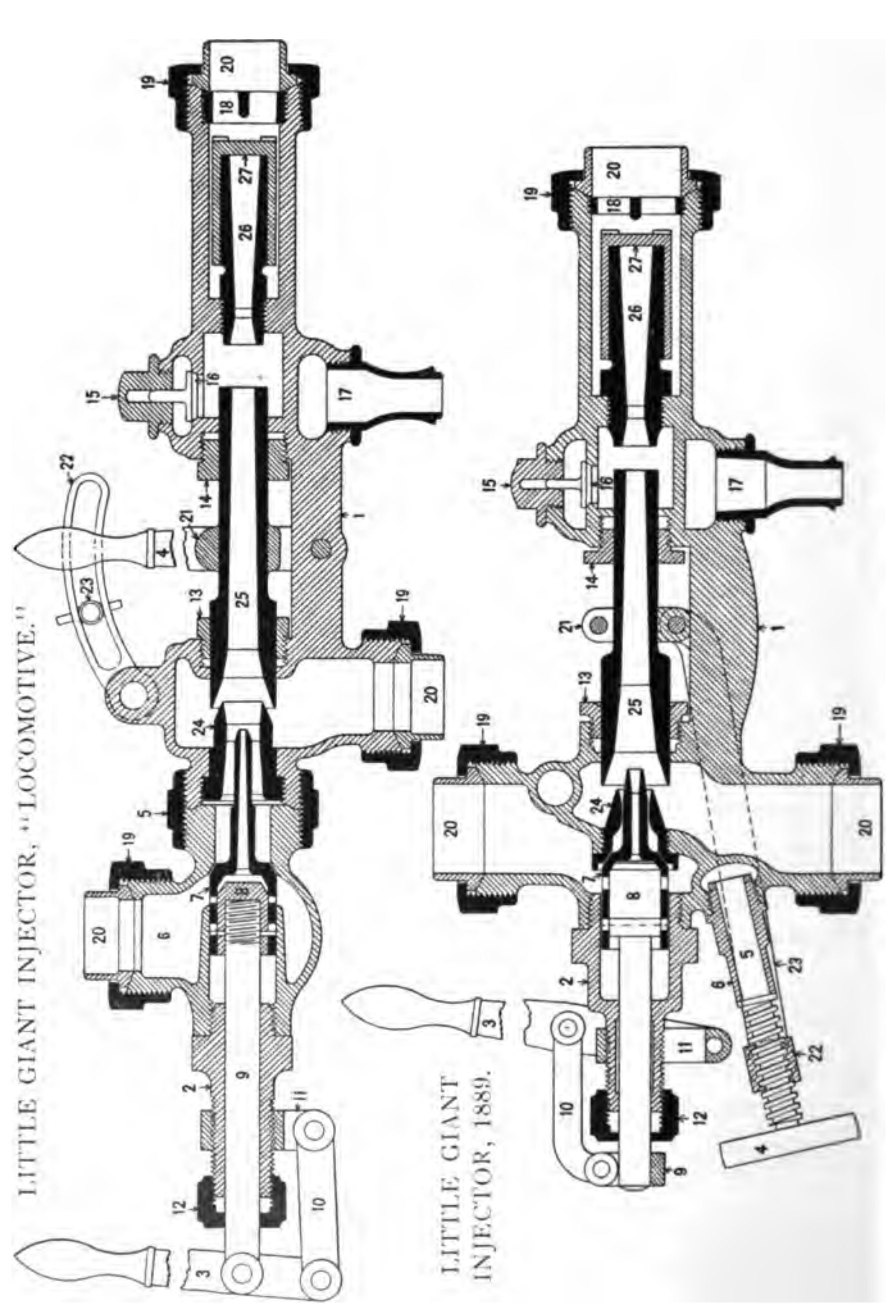
ECLIPSE INJECTOR.

Plate 72. ELEVADOS.

Elevamento . . .	1. Handle of Regulating Valve.
Elevando	2. Small Nut holding in Stem.
Elevareis	3. Jam Nut.
Elevarem	4. Main Nut holding Injector in Shell.
Elevaremus. . . .	5. Stem.
Elevariais.	6. Lifting Jet.
Elevarono.	7. Combining Tube.
Elevassem	8. Discharge Tube.
Elevassimo	9. Check Valve.
Elevateur	10. Space for Packing.
Elevatezza	11. Follower for confining Packing.
Elevating.	12. Shell.
Elevator.	13. Body.
Elevatoris.	14. Adjusting Tube regulating Water and Steam Supply.
Elevatrice.	15. Body of Overflow Valve.
Elevavamo	16. Overflow Valve.
Elevavate.	17. " " Spring.
Elevazione	18. Threaded End of Body.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages 213 to 221.

Plate 73.



LITTLE GIANT INJECTOR, "LOCOMOTIVE."

LITTLE GIANT INJECTOR, 1889.

For de: cription, see page 401

For description, see page 402.

LITTLE GIANT INJECTOR, "LOCOMOTIVE."

Plate 73. ELEVENTH.

Eleveranno . . .	1.	Body.
Eleverebbe . . .	2.	Stuffing Box.
Eleveremo. . . .	3.	Starting Lever.
Eleveresti	4.	Injector Lever.
Elevero	5.	Right and Left Nut.
Eleverunt	6.	Starting Valve Body.
Eleves	7.	Main Steam Valve.
Eleveurs.	8.	Jet Valve.
Elevimus	9.	" " Stem.
Elevriez	10.	Starting Valve Link.
Elezionano . . .	11.	Fulcrum.
Elezionare. . . .	12.	Stuffing Box Nut.
Elezionava . . .	13.	Large Packing Nut.
Eleziono.	14.	Small " "
Elfbladig	15.	Overflow Cap.
Elfdaagsch . . .	16.	" Valve.
Elfdehalf	17.	" Nozzle.
Elfderlei.	18.	Check Valve Stop.
Elfenbein	19.	Coupling Nut.
Elfenbusch . . .	20.	Swivel.
Elfenmaus . . .	21.	Combining Tube Clamp.
Elfenspuk. . . .	22.	Quadrant.
Elfenweiss . . .	23.	Thumb Screw.
Elferberg	24.	Steam Tube.
Elfgesang. . . .	25.	Combining Tube.
Elfhelmig	26.	Discharge Tube.
Elfhoek	27.	Check Valve.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. **For code numbers, see pages 213 to 221.**

LITTLE GIANT INJECTOR, 1889.

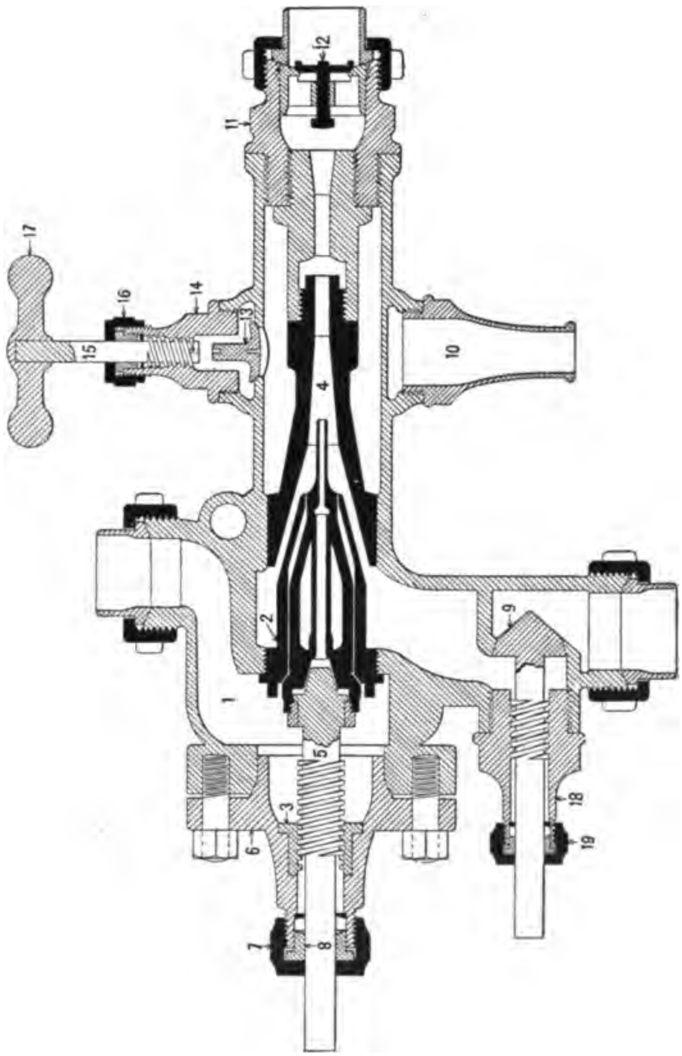
Plate 73. ELFHOEKIG.

See page 400.

Elfin	1.	Body.
Elfjarig	2.	Stuffing Box.
Elfmaal	3.	Starting Lever.
Elfmeilig	4.	Adjusting Wheel.
Elfpaarig	5.	" " Stem.
Elfrank	6.	" Stem Holder.
Elfreihig	7.	Main Steam Valve.
Elfrippig	8.	Jet Valve.
Elfstijlig	9.	" " Clamp.
Elftaegig	10.	Starting Valve Link.
Elftal	11.	Fulcrum.
Elftnet	12.	Stuffing Box Nut.
Elfvoud	13.	Large Packing Nut.
Elfvoudig	14.	Small " "
Elhanan	15.	Overflow Cap.
Eliacus	16.	" Valve.
Eliahba	17.	" Nozzle.
Eliakim	18.	Check Valve Stop.
Eliantemo	19.	Coupling Nut.
Eliasaph	20.	Swivel.
Eliashib	21.	Combining Tube Clamp.
Eliathah	22.	Crosshead.
Eliberamus	23.	Side Bars.
Eliberas	24.	Steam Tube.
Elibero	25.	Combining Tube.
Elicaon	26.	Discharge Tube.
Eliciano	27.	Check Valve.

In ordering parts for injector, give in all cases the makers' number stamped on the injector. For code numbers, see pages 213 to 221.

Plate 74.



NATIONAL AND N. T. INJECTOR.

For description of plate, see page 404.

NATIONAL AND N. T. INJECTOR.

Plate 74. ELICIENDOS.

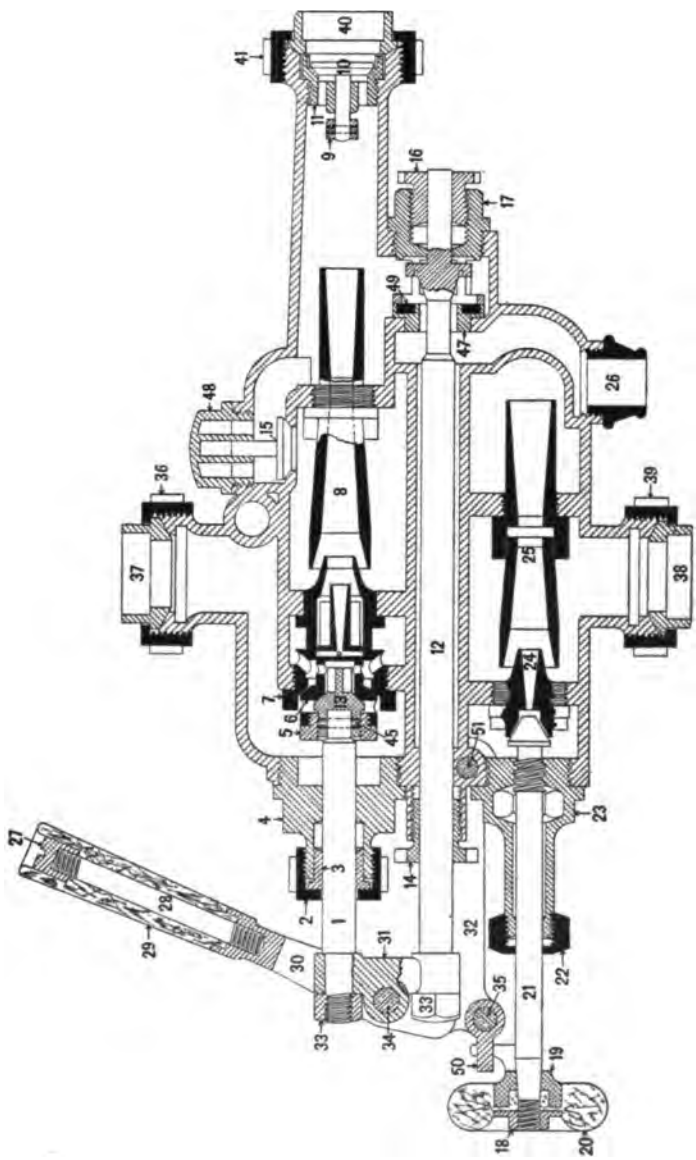
See page 403.

Eliciendum . .	1.	Body.
Elicited.	2.	Cone.
Eliciting	3.	Stand Nut.
Elicito	4.	Delivery Tube.
Elicosofia . . .	5.	Ram and Spindle.
Elicuerunt . . .	6.	Stand.
Elicuimus . . .	7.	" Cap.
Elicuisti	8.	" Gland.
Elidemmo . . .	9.	Water Valve.
Elidendo	10.	Overflow Nozzle.
Elidesse	11.	Delivery Tube Nut.
Elidevamo . . .	12.	End Check Valve.
Elidevate . . .	13.	Overflow Valve.
Elienai	14.	" Stand.
Eliezer	15.	" Spindle.
Eligam	16.	" Cap.
Eligendi	17.	" Lever.
Eligendos . . .	18.	Stand of Water Valve.
Eligendum. . .	19.	" Cap.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages 213 to 221.

Plate 75.

METROPOLITAN DOUBLE TUBE LOCOMOTIVE INJECTOR.



For description of plate, see pages 406 and 407.

METROPOLITAN DOUBLE TUBE LOCOMOTIVE INJECTOR.

Plate 75. ELIGERE.

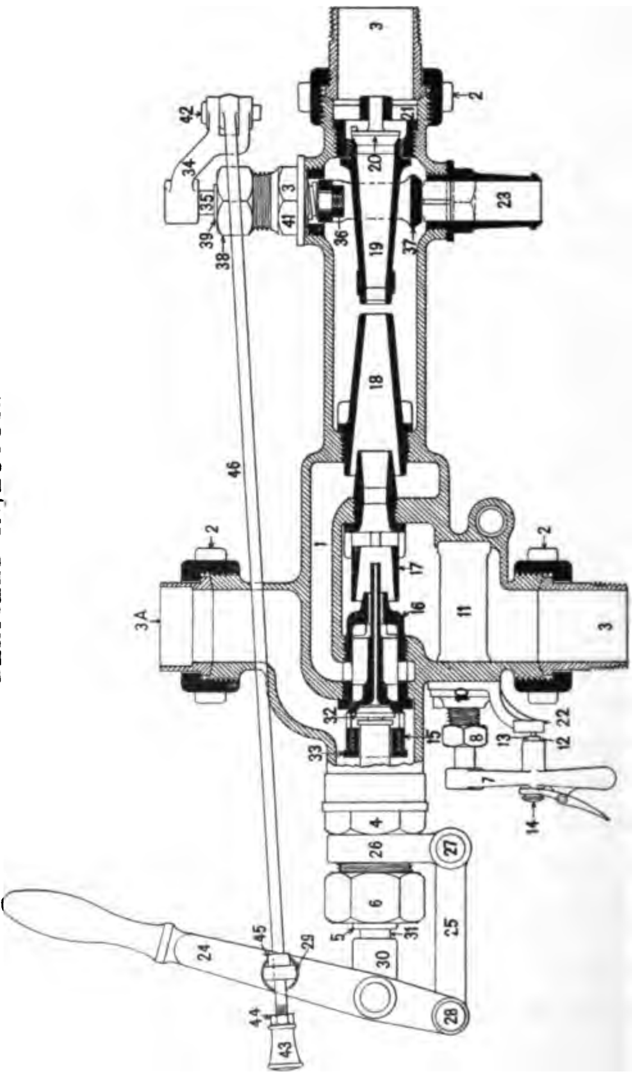
See page 405.

Eligibly	1.	Steam Valve Stem.
Eligieron	2.	Packing Nut for No. 1.
Eligius	3.	Gland for No. 1.
Eligma	4.	Steam Centre Piece.
Elihoreph	5.	" Swivel Ring.
Elihu	6.	" Valve.
Elijamos	7.	Forcing Steam Tube.
Elikah	8.	" Combining Tube.
Elimant	9.	Line Check Ring.
Elimassem	10.	" " Valve.
Elimasti	11.	Seat for Line Check.
Elimatius	12.	Overflow Valve Stem.
Elimatos	13.	Auxiliary Steam Valve.
Elimavisti	14.	Gland for No. 12.
Elimberis	15.	Overflow Valve.
Eliminacao	16.	" Packing Gland.
Eliminammo	17.	" Centre Piece.
Eliminamos	18.	Regulating Valve Handle Nut.
Eliminant	19.	" " Wheel Disc.
Eliminaron	20.	" " Wheel.
Eliminassi	21.	" " Stem.

Eliminatum	22.	Packing Nut for No. 21.
Eliminava	23.	Regulating Valve Centre Piece.
Eliminiez	24.	Lifting Steam Tube.
Eliminons	25.	" Combining Tube.
Elimiotis	26.	Overflow Nozzle.
Elimpidas	27.	Lever Nut.
Elimpidavi	28.	" Rod.
Elimpido	29.	" Handle.
Elingo	30.	Lever.
Elinguamus	31.	Connecting Link.
Elinguatio	32.	Fulcrums.
Elinguavi	33.	Nuts for Stems Nos. 1 and 12.
Elinguibus	34.	Lever Bolts.
Elinguid	35.	Fulcrum Bolt.
Elinxerunt	36.	Union Nut, Steam End.
Elinxi	37.	Tail Pipe, " "
Eliocarpo	38.	" " Suction "
Eliocometa	39.	Union Nut, " "
Eliocroca	40.	Tail Pipe, Delivery "
Eliofobia	41.	Union Nut, " "
Eliolite	42.	Nut for Bolt No. 34.
Eliometro	43.	" " " " 35.
Elionure	44.	Overflow Funnel.
Elioscopio	45.	Pin for Auxiliary Steam Valve.
Eliose	47.	Overflow Valve Seat.
Eliostato	48.	" Cap.
Eliota	49.	Disc for Overflow Valve Seat.
Eliotropia	50.	Lever Stop.
Eliphalet	51.	Body Bolt.
Elipsoide	52.	Nut for same.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. **For code numbers, see pages 213 to 221.**

Plate 76.



BELFIELD INJECTOR.

BELFIELD INJECTOR.

Plate 76. ELIQUAMENT.

Eliquati	1. Injector Body.
Eliquation . . .	2. Coupling Nut.
Eliquescis	3. Swivel for Iron Pipe.
Eliquesco	3A. " " Copper Pipe.
Eliquia	4. Stuffing Box for Starting Stem.
Eliquium	5. Gland in No. 4.
Elirait	6. Nut for No. 4.
Eliront	7. Regulating Valve.
Elisabeth	8. Nut for No. 10.
Elisachar	10. Regulating Plug Stuffing Box.
Elisaeus	11. " Plug.
Eliseos	12. Spring in No. 7.
Eliserunt	13. Pawl.
Elisferica	14. Button on No. 13.
Elishamah . . .	15. Lifting Tube.
Elishaphat . . .	16. First Steam Nozzle.
Elisheba	17. " Combining Tube.
Elision	18. Second " "
Elisionis	19. Delivery Tube.
Elisirvite	20. Check Valve.

(Continued on page 410.)

Plate 76, continued.

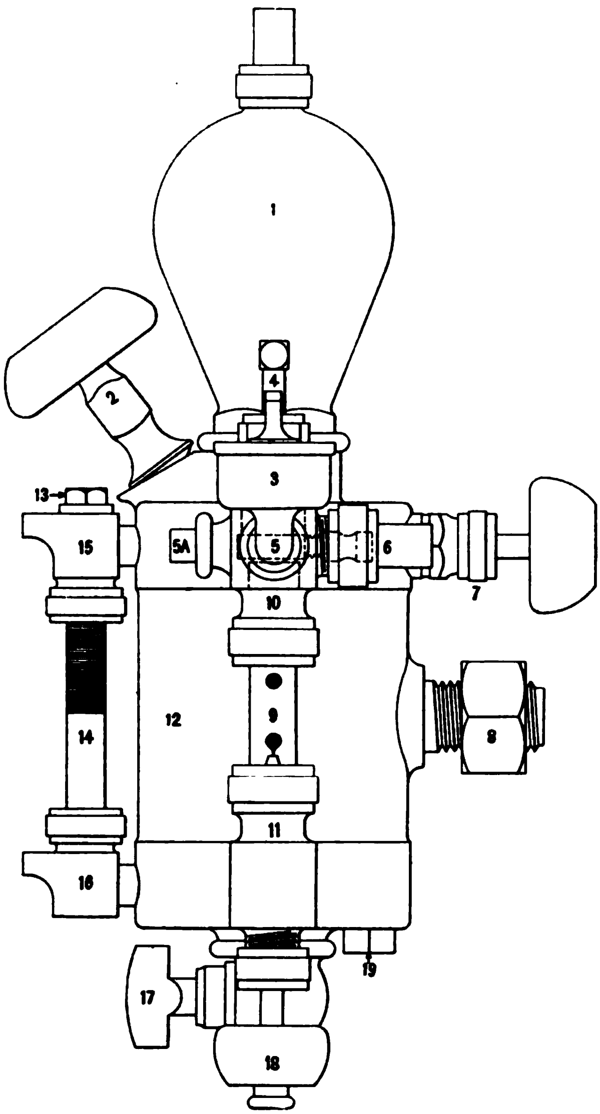
See page 408.

Elisissem. . . 21. Guide Ring for Check Valve.
Elisisti . . . . 22. Quadrant.
Elisor. . . . . 23. Overflow Nozzle.
Elisorum. . . 24. Starting Lever.
Elissaeo . . . 25. Link.
Elissaeus. . . 26. Lever Clamp.
Elisseen . . . 27. Bolt through No. 25 and No. 26.
Elitraria . . . 28. Pin and Cotter through No. 24 and No. 25.
Elitrocele . . 29. Pin and Cotter through No. 24 to move Rod No. 46.
Elittiche . . . 30. Crosshead on No. 31.
Elittico. . . . 31. Starting Stem.
Elixacao . . . 32. " Valve.
Elixamus. . . 33. Lock Nut to Connect No. 15 to No. 31.
Elixate . . . . 34. Lever on Overflow Valve.
Elixation. . . 35. Stem for " "
Elixatura. . . 36. Nut to Connect No. 35 to No. 37.
Elixaturis . . 37. Overflow Valve.
Elixing . . . . 38. Nut for No. 41.
Elixires. . . . 39. Gland in No. 41.
Elixorum. . . 41. Overflow Valve Stuffing Box.
Elixura. . . . 42. Pin through No. 34 and No. 46.
Elizaphan . . 43. Knob on Rod No. 46.
Eliziario . . . 44. Lock Nut to hold No. 43.
Elizur . . . . 45. Stop on No. 46 to open Overflow Valve.
Eljen . . . . . 46. Overflow Valve Rod.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages, 213 to 221.

Plate 77.

NATHAN SIGHT FEED CYLINDER LUBRICATOR.



For description of plate, see page 412.

NATHAN SIGHT FEED CYLINDER LUBRICATOR.

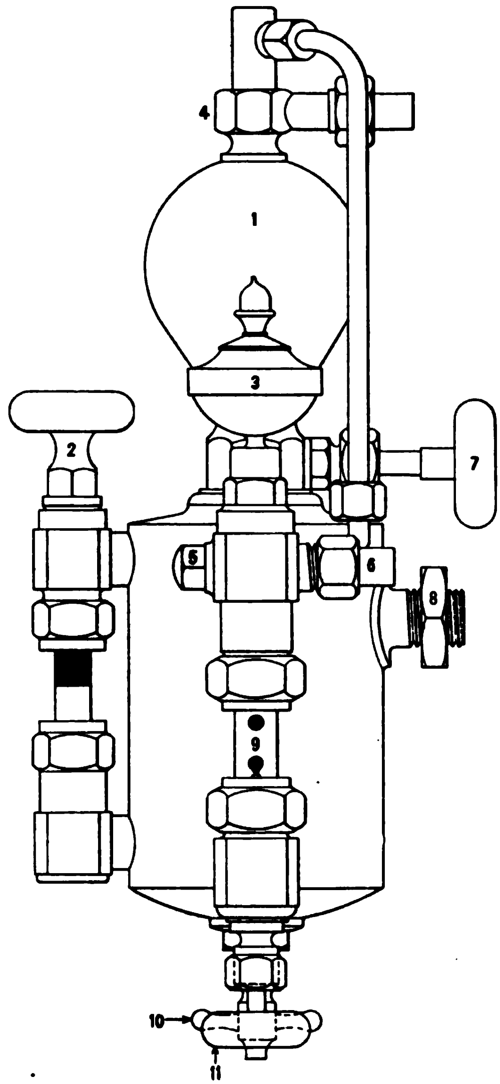
Plate 77. ELKAITE.

See page 411.

Elkander	1. Condenser.
Elkesaite	2. Filling Plug.
Elkosh.	3. Auxiliary Oiler.
Ellagique	4. Safety Valve.
Ellagite	5. Reducing Plug.
Ellanodici. . . .	5A. Blow-off "
Ellasar	6. Delivery Nut and Coupling.
Ellbogen	7. Water Valve.
Ellbuth	8. Stud Nut.
Elleboog	9. Sight Feed Glass.
Elleborina . . .	10. Upper Sight Bracket and Nut.
Ellemaat	11. Lower " " " "
Ellendig.	12. Body.
Ellenhard	13. Gauge Glass Plug.
Ellenhoch	14. " Glass.
Elleni	15. Upper Gauge Bracket and Nut.
Elleniche	16. Lower " " " "
Ellenico	17. Waste Cock.
Ellenijker	18. Regulating Valve.
Ellenmass. . . .	19. Bottom Plug.

Plate 78.

DETROIT SIGHT FEED CYLINDER LUBRICATOR.



For description of plate, see page 414.

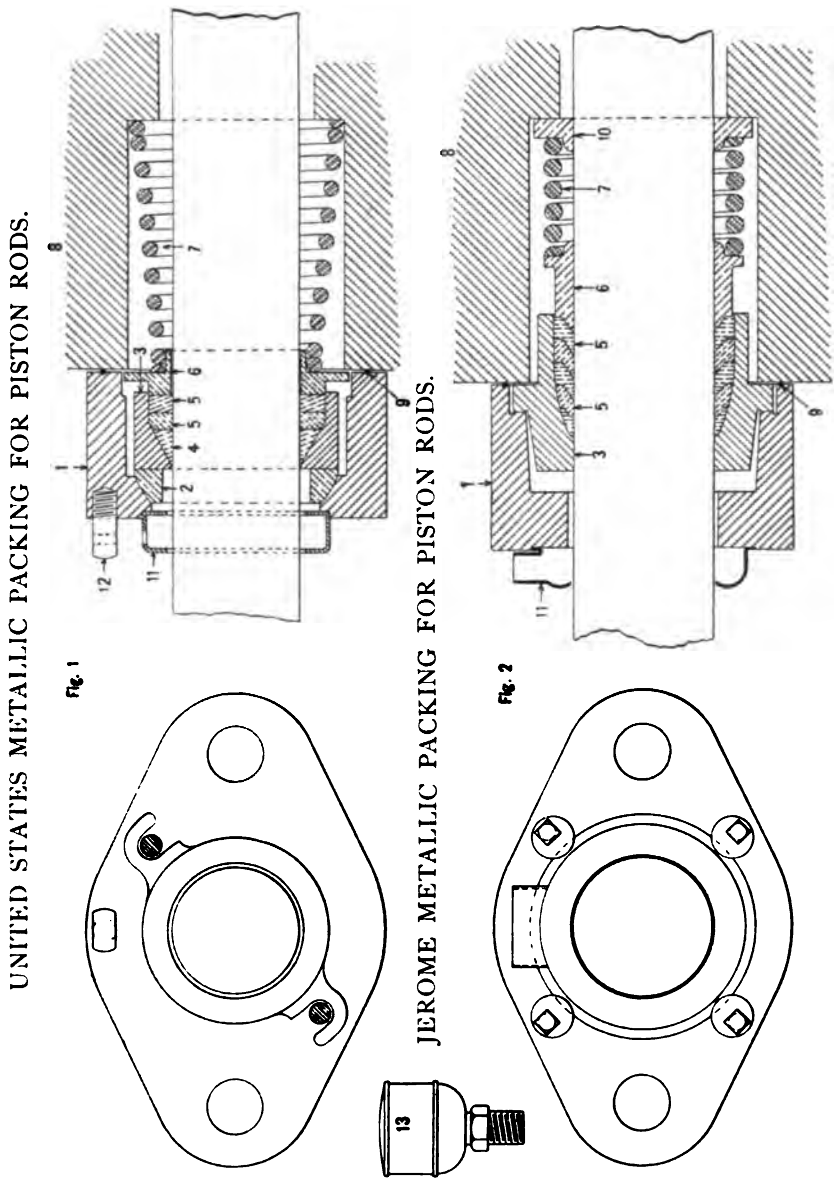
DETROIT SIGHT FEED CYLINDER LUBRICATOR.

Plate 78. ELLENPRINZ.

See page 413.

Ellenstab . . .	1. Condenser.
Ellenwaare. .	2. Filler Plug.
Ellenzahl . . .	3. Auxiliary Oiler.
Ellepijp. . . .	4. Connection for Boiler Pressure.
Ellepijpen . .	5. Plugs to fill Glasses with Water when Lubricator is first attached.
Elleridder . .	6. Tail Pipe.
Ellerina. . . .	7. Water Valve.
Ellesque . . .	8. Jam Nut.
Ellewaar . . .	9. Sight Feed Glass.
Ellewinkel . .	10. Drain Valve.
Ellicott. . . .	11. Regulating Valve.

Plate 79.



For description of plate, see page 416.

METALLIC PISTON ROD PACKING.

Plate 79. ELLINGE.

See page 415.

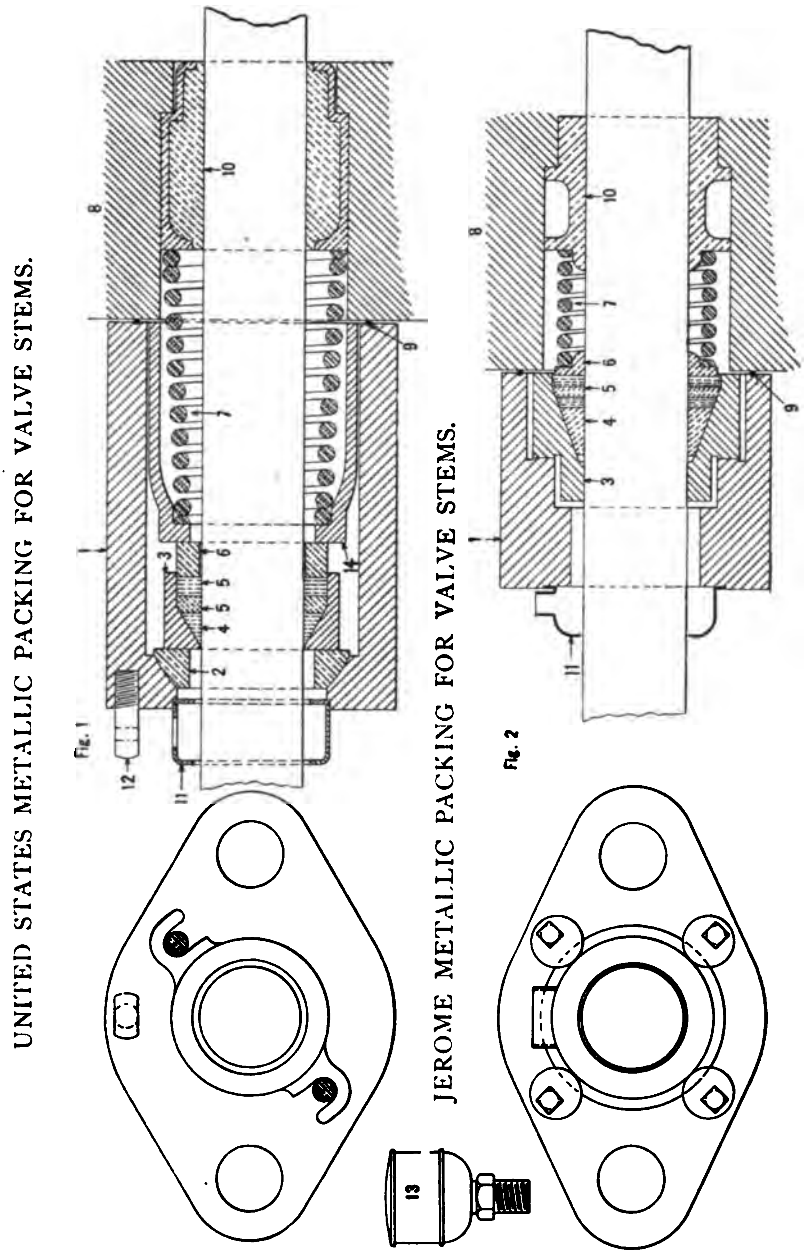
FIG. 1.—**Ellinger.**

FIG. 2.—**Ellingerry.**

Ellipanthe . .	1.	Packing Case.
Ellipsaire . .	2.	Ball Joint.
Ellipsis . . .	3.	Vibrating Cup.
Ellipsoid . .	4.	Babbitt Ring.
Elliptical . .	5.	" "
Elliptico . . .	6.	Follower.
Elliptisch . .	7.	Coil Spring.
Ellisia	8.	Stuffing Box.
Ellissoide . .	9.	Copper Wire Joint.
Ellkatze . . .	10.	Neck Ring.
Ellobie	11.	Swab Holder.
Ellwand . . .	12.	Oil Cup Bracket.
Ellychnie . .	13.	" Cup.

In ordering repairs, give in all cases the number stamped on packing case.

Plate 80.



For description of plate, see page 418.

METALLIC VALVE STEM PACKING.

Plate 80. ELLYCHNIUM.

(See page 417.)

FIG. 1.—**Ellychnor.**

FIG. 2.—**Ellychnoty.**

Elmakin . . .	1.	Packing Case.
Elmigere . .	2.	Ball Joint.
Elminti . . .	3.	Vibrating Cup.
Elmintiasi . .	4.	Babbitt Ring.
Elmintico . .	5.	" "
Elminzia . .	6.	Follower.
Elmodam . .	7.	Coil Spring.
Elmsfeuer . .	8.	Stuffing Box.
Elmsley . . .	9.	Copper Wire Joint.
Elocandi . .	10.	Bushing.
Elocandum .	11.	Swab Holder.
Elocavimus .	12.	Oil Cup Bracket.
Elocavisti . .	13.	" Cup.
Elocher . . .	14.	Preventer.

In ordering repairs, give in all cases the number stamped on packing case.

SPECIFICATION CODE.

In addition to the foregoing code words for parts of locomotives, the following code words are provided for use in connection therewith, or to express details of specifications for locomotives :

Prozaisch . . Steel boiler, steel fire box, iron flues, No. 12 wire gauge.
Prozastijl. . . Steel tires.
Prozent . . . Steel wrist pins.
Prozenten . . Hammered iron wrist pins.
Prozoique . . Iron stay bolts.
Prude . . . . Fire-brick arch for bituminous coal burning locomotives.
Prudement . . Dry pipe of wrought iron.
Prudencial . . Dry pipe, copper.
Prudencio . . Stack, grates, and smoke box to suit fuel.
Prudente . . . Chilled cast iron engine truck wheels.
Prudently . . Wrought centre, steel tired engine truck wheels.
Prudenza. . . Automatic sight feed lubricator for cylinders.
Pruderie . . . Piston rods of iron.
Prudish . . . Piston rods of steel.
Prudishly . . Guides of steel.
Prudore . . . Guides of cast iron.
Pruebes . . . Guides of wrought iron, case hardened.
Pruefbar . . . Crossheads of cast iron.
Pruefen . . . Crossheads of steel.
Pruefling . . . Slide valves, plain ——— pattern.
Pruefstein . . Slide valves, balanced pattern.
Pruefung . . . Axles of hammered iron.
Pruefungen . Axles of steel.
Pruefzeit . . . Metallic packing for piston rods and valve stems.
Pruegeln . . . Cab of wood.
Prueggiano . . Cab of iron.
Prueggiare . . Cab to have double roof with air-space between, and ventilator in roof.
Prueggiava . . Spring buffers, front and back.
Prueggio . . . Pilot of wood, braced with iron.

Prugnolo . . . Guard rails, front and back.

Pruido . . . . Furniture: Engine to be furnished with one sand box (two sand boxes for larger size tank engines), stand for head lamp, two whistles, blow-off cock, blower and safety valves, steam gauge, cab lamp, two glass water gauges with lamps; also a complete set of tools, consisting of two traversing screw jacks and levers, one heavy pinch bar with steel point and heel, complete set of wrenches to fit all nuts and bolts on engine, including two monkey wrenches, one set of driving box packing tools, one machinist's hammer, one soft hammer, three cold chisels (two flat and one cape), one long spout quart oil can, one two gallon oil can, one tallow pot, one torch, engineer's arm rest, one extra fusible plug, signal gong, cab seats, cab seat cushions, one poker, one scraper, one slice bar, and one scoop shovel.

Pruikebol . . Headlight, with silvered reflector.

Pruikedoos . . Three 8″ bull's eyes, with red, white, and green lenses.

Pruikenet . . Finish: Cylinders lagged with same material as boiler, and neatly cased with iron, painted. Cylinder head covers of hydraulic forged steel, painted or polished. Steam chests with cast iron tops; bodies cased with iron, painted. Dome lagged with same material as boiler, with painted iron casing on body and cast iron top and bottom rings.

Pruikerig . . . Boiler lagged with sectional magnesia.

Pruikjes . . . Boiler lagged with sectional asbestos.

Pruilmond . . Jacket secured by iron bands.

Pruimeboon . Jacket secured by brass bands.

Pruimedant . Hand rails of iron.

Pruimekern . Hand rails of brass.

Pruimensap . Running boards of iron, with nosings of iron.

Pruimers . . . Wheel cover nosings of iron.

Pruinarum . . Wheel cover nosings of brass.

Pruinose . . . Engine and tender to be well painted and varnished. Lettering and numbering to be as specified by purchaser.

Pruinosos . . . General features of construction.

Pruir . . . . . All finished movable nuts and all wearing surfaces of valve motion made of steel, or iron case hardened.

Pruivel . . . All wearing brasses made of phosphor bronze.

Prulachtig . . All wearing brasses made of ingot copper and tin, alloyed in proportion to give best mixture for wearing bearings.

Prullig . . . . All threads on bolts to United States standard.

Prumnides . . Tender: Tank of steel strongly put together, with angle iron corners and well braced.

Prumo . . . . Tender frame substantially built of channel iron, strongly braced; floor of iron.

Prumulace . . Tender trucks made with wrought iron, equalized frames; springs, crucible cast steel, tempered in oil.

Prunaia . . . Wheels of chilled cast iron.

Pruneaux . . Hand brake on all tender wheels.

Prunelaies . . Metallic brake beams.

Prunella . . . Tool boxes of iron, fitted with locks and keys.

The details above mentioned refer to the usual practice of the Works, for export locomotives. Code words are provided for special details of construction, as follows:

Pruniforme . . Automatic bell ringer.

Pruning . . . Baldwin Locomotive Works steam brake.

Prunkbett . . Steam brake on two pairs of driving wheels.

Prunkhalle . . Steam brake on three pairs of driving wheels.

Prunkloser . . Steam brake on four pairs of driving wheels.

Prunkspiel . . Steam brake on tender.

Prunksucht . . Hand screw brake, to operate on steam brake.

Prunktitel . . American Brake Company's steam brake.

Prunkvoll . . American Brake Company's steam brake on two pairs of driving wheels.

Prunkwerk . . American Brake Company's steam brake, equalized

pressure on forward side of two pairs of driving wheels.

Prunophore . American Brake Company's steam brake, equalized pressure on forward side of three pairs of driving wheels.

Prunosa . . . American Brake Company's steam brake, equalized pressure on forward side of four pairs of driving wheels.

Prunulis . . . American Brake Company's steam brake, equalized pressure on forward side of five pairs of driving wheels.

Prunulorum . American Brake Company's steam brake on tender.

Pruriebat . . Westinghouse quick action automatic air brake.

Pruriente . . Westinghouse quick action automatic air brake on two pairs of driving wheels.

Prurigem . . . Westinghouse quick action automatic air brake on two pairs of driving wheels and tender.

Prurigine . . . Westinghouse quick action automatic air brake, equalized pressure on forward side of three pairs of driving wheels only.

Pruriginis . . Westinghouse quick action automatic air brake, equalized pressure on forward side of four pairs of driving wheels only.

Pruriosi . . . Westinghouse quick action automatic air brake, equalized pressure on forward side of five pairs of driving wheels only.

Pruriosos . . Westinghouse quick action automatic air brake, equalized pressure on forward side of three pairs of driving wheels and tender.

Pruriteux . . Westinghouse quick action automatic air brake, equalized pressure on forward side of four pairs of driving wheels and tender.

Pruritivi . . . Westinghouse quick action automatic air brake, equalized pressure on forward side of five pairs of driving wheels and tender.

Pruritivos . . Westinghouse train signal.

Prusaeus . . . Westinghouse vacuum brake.

Prusensium . Westinghouse vacuum brake on tender wheels only (including ejector and diaphragms).

Prusiacus . . Westinghouse vacuum brake on two pairs of driving wheels only.

Prusianos . . Westinghouse vacuum brake on forward side of two pairs of driving wheels only.

Prusica . . . Westinghouse vacuum brake on tender and forward side of two pairs of driving wheels.

Prusicos . . . Westinghouse vacuum brake on forward side of three pairs of driving wheels only.

Prussian . . . Westinghouse vacuum brake on tender and forward side of three pairs of driving wheels.

Prussiates . . Westinghouse vacuum brake on forward side of four pairs of driving wheels only.

Prussico . . . Westinghouse vacuum brake on tender and forward side of four pairs of driving wheels.

Prussique . . Westinghouse vacuum brake on forward side of five pairs of driving wheels only.

Prutenic . . . Westinghouse vacuum brake on tender and forward side of five pairs of driving wheels.

Pruttelig . . . Eames vacuum brake.

Prutzeln . . . Eames vacuum brake on tender and train wheels only.

Pryest . . . . Eames vacuum brake on two pairs of driving wheels only.

Pryingly . . . Eames vacuum brake on two pairs of driving wheels and tender.

Prymnesia . . Eames vacuum brake on forward side of two pairs of driving wheels only.

Prymnesium . Eames vacuum brake on tender and forward side of two pairs of driving wheels.

Prymnessos . Eames vacuum brake on forward side of three pairs of driving wheels only.

Prymnesus . . Eames vacuum brake on tender and forward side of three pairs of driving wheels.

Prytanee . . . Eames vacuum brake on forward side of four pairs of driving wheels only.

Prytaneion . . Eames vacuum brake on tender and forward side of four pairs of driving wheels.

Psacum . . . English (Vacuum Brake Company's) automatic vacuum brakes.

Psadiroma . . English automatic vacuum brake ejector for operating train brakes only.

Psaliceres . . English automatic vacuum brake ejector for tender wheels only.

Psalio . . . . English automatic vacuum brake ejector for four driving wheels and tender, outside equalized pressure.

Psallebat . . . English automatic vacuum brake ejector for four driving wheels only, outside equalized pressure.

Psallendum . English automatic vacuum brake ejector for six driving wheels and tender, outside equalized pressure.

Psallerunt . . English automatic vacuum brake ejector for six driving wheels only, outside equalized pressure.

Psallette . . . English automatic vacuum brake ejector for eight driving wheels and tender, outside equalized pressure.

Psallidies . . English automatic vacuum brake ejector for eight driving wheels only, outside equalized pressure.

Psallimus . . English automatic vacuum brake ejector for ten driving wheels and tender, outside equalized pressure.

Psallisti . . . English automatic vacuum brake ejector for ten driving wheels only, outside equalized pressure.

Psallunt . . . English (Vacuum Brake Company's) non-automatic vacuum brakes.

Psalm . . . . English non-automatic vacuum brake ejector for operating train brakes only.

Psalmata . . . English non-automatic vacuum brake ejector for tender wheels only.

Psalmboek . . English non-automatic vacuum brake ejector for four driving wheels and tender, outside equalized pressure.

Psalmbuch . . English non-automatic vacuum brake ejector for four driving wheels only, outside equalized pressure.

Psalmear . . . English non-automatic vacuum brake ejector for six driving wheels and tender, outside equalized pressure.

Psalmicen . . English non-automatic vacuum brake ejector for six driving wheels only, outside equalized pressure.

Psalmicini . . English non-automatic vacuum brake ejector for eight driving wheels and tender, outside equalized pressure.

Psalmique . . English non-automatic vacuum brake ejector for eight driving wheels only, outside equalized pressure.

Psalmista . . English non-automatic vacuum brake ejector for ten driving wheels and tender, outside equalized pressure.

Psalmistis . . English non-automatic vacuum brake ejector for ten driving wheels only, outside equalized pressure.

Psalmodiar. . Screw brake.

Psalmodize . Hand screw brake on two pairs of driving wheels.

Psalter . . . . Hand screw brake on three pairs of driving wheels.

Psalterium . . Hand screw brake instead of windlass brake on tender.

Psamethos . . Brass dome casing.

Psamenit . . . Brass steam chest casing.

Psametico . . Brass case chronometer lever marine clock.

Psammathus . Driving boxes of brass.

Psamocole . . Driving boxes of cast steel.

Psamode . . . Driving boxes of wrought iron.

Psamodus . . Fire box, Belpaire pattern.

Psamogene . . Fire box of copper.

Psamolepe . . Fire brick supported on water tubes instead of angle irons or studs.

Psamures . . Sliding fire door.

Psaphis . . . Copper tubes.

Psaphon . . . Brass tubes.

Psaranorum . Copper tubes, 1½″ diameter, No. 13 wire gauge, 1.63 pounds per foot.

Psaranos . . . Copper tubes, 1½″ diameter, No. 12 wire gauge, 1.85 pounds per foot.

Psararanum . Copper tubes, 1½″ diameter, No. 11 wire gauge, 2.02 pounds per foot.

Psarisome . . Copper tubes, 1½″ diameter, No. 10 wire gauge, 2.24 pounds per foot.

Psaroide . . . Copper tubes, 1¾″ diameter, No. 13 wire gauge, 1.92 pounds per foot.

Psarolite . . . Copper tubes, 1¾″ diameter, No. 12 wire gauge, 2.18 pounds per foot.

Psaronio . . . Copper tubes, 1¾″ diameter, No. 11 wire gauge, 2.39 pounds per foot.

Psaronites . . Copper tubes, 1¾″ diameter, No. 10 wire gauge, 2.65 pounds per foot.

Psarophole . . Copper tubes, 2″ diameter, No. 13 wire gauge, 2.21 pounds per foot.

Psathyrose . . Copper tubes, 2″ diameter, No. 12 wire gauge, 2.51 pounds per foot.

Psatura . . . Copper tubes, 2″ diameter, No. 11 wire gauge, 2.75 pounds per foot.

Psautier . . . Copper tubes, 2″ diameter, No. 10 wire gauge, 3.06 pounds per foot.

Pseboa . . . . Copper tubes, 2¼″ diameter, No. 13 wire gauge, 2.50 pounds per foot.

Psecade . . . Copper tubes, 2¼″ diameter, No. 12 wire gauge, 2.85 pounds per foot.

Psecadies . . Copper tubes, 2¼″ diameter, No. 11 wire gauge, 3.12 pounds per foot.

Psefororia . . Copper tubes, 2¼″ diameter, No. 10 wire gauge, 3.46 pounds per foot.

Pselaphes . . Brass tubes, 1½″ diameter, No. 13 wire gauge, 1.63 pounds per foot.

Pselchis . . . Brass tubes, 1½″ diameter, No. 12 wire gauge, 1.85 pounds per foot.

Pselions . . . Brass tubes, 1½″ diameter, No. 11 wire gauge, 2.02 pounds per foot.

Pseliumene . Brass tubes, 1½″ diameter, No. 10 wire gauge, 2.24 pounds per foot.

Psellisme . . . Brass tubes, 1¾″ diameter, No. 13 wire gauge, 1.92 pounds per foot.

Psellismus . . Brass tubes, 1¾″ diameter, No. 12 wire gauge, 2.18 pounds per foot.

Psenerus . . . Brass tubes, 1¾″ diameter, No. 11 wire gauge, 2.39 pounds per foot.

Psephisme . . Brass tubes, 1¾″ diameter, No. 10 wire gauge, 2.65 pounds per foot.

Psephite . . . Brass tubes, 2″ diameter, No. 13 wire gauge, 2.21 pounds per foot.

Psephobole . . Brass tubes, 2″ diameter, No. 12 wire guage, 2.51 pounds per foot.

Psepholax . . Brass tubes, 2″ diameter, No. 11 wire gauge, 2.75 pounds per foot.
Pseques . . . Brass tubes, 2″ diameter, No. 10 wire gauge, 3.06 pounds per foot.
Psetta . . . . Brass tubes, 2¼″ diameter, No. 13 wire gauge, 2.50 pounds per foot.
Psettarum . . Brass tubes, 2¼″ diameter, No. 12 wire gauge, 2.85 pounds per foot.
Psettis . . . . Brass tubes, 2¼″ diameter, No. 11 wire gauge, 3.12 pounds per foot.
Pseudalees . . Brass tubes, 2¼″ diameter, No. 10 wire gauge, 3.46 pounds per foot.
Pseudarade . . Iron tubes.
Pseudaspis . . Iron tubes, 1½″ diameter, No. 13 wire gauge.
Pseudechis . . Iron tubes, 1½″ diameter, No. 12 wire gauge.
Pseudelaps . . Iron tubes, 1½″ diameter, No. 11 wire gauge.
Pseuderyx . . Iron tubes, 1½″ diameter, No. 10 wire gauge.
Pseudiosma . Iron tubes, 1¾″ diameter, No. 13 wire gauge.
Pseudo . . . . Iron tubes, 1¾″ diameter, No. 12 wire gauge.
Pseudoafia . . Iron tubes, 1¾″ diameter, No. 11 wire gauge.
Pseudoasma . Iron tubes, 1¾″ diameter, No. 10 wire gauge.
Pseudocato . . Iron tubes, 2″ diameter, No. 13 wire gauge.
Pseudocoia . . Iron tubes, 2″ diameter, No. 12 wire gauge.
Pseudodox . . Iron tubes, 2″ diameter, No. 11 wire gauge.
Pseudogyne . Iron tubes, 2″ diameter, No. 10 wire gauge.
Pseudolien . . Iron tubes, 2¼″ diameter, No. 13 wire gauge.
Pseudology . . Iron tubes, 2¼″ diameter, No. 12 wire gauge.
Pseudome . . Iron tubes, 2¼″ diameter, No. 11 wire gauge.
Pseudomeno . Iron tubes, 2¼″ diameter, No. 10 wire gauge.
Pseudomys . . Copper ends brazed on iron tubes.
Pseudonymo . Frames outside of driving wheels.
Pseudornis . . Glass water gauge on tender.
Pseudosmia . Extra headlight, in addition to one headlight or three bull's eyes.
Pseudova . . . Oil cups on driving boxes.
Pseudovum . . Brass piston rod and valve stem glands.
Pseudozene . . Brass throttle valve seat.
Pseustes . . . Extra pilot.
Pshaw . . . . Piston rods extended through front cylinder heads.

Psiadia . . . . Retaining rings for driving wheels.
Psiche . . . . Belpaire combined screw and lever reverse gear.
Psichico . . . Side rods, I section, for two pairs of driving wheels.
Psichine . . . Side rods, I section, for three pairs of driving wheels.
Psicoda . . . Side rods, I section, for four pairs of driving wheels.
Psicologia . . Side rods, I section, for five pairs of driving wheels.
Psicologo . . . Main rods, I section.
Psicrotico . . . Steam or air sanding devices.
Psilarum . . . Piston slide valves.
Psiletes . . . . Boyer speed recorder.
Psillo . . . . . Copper steam pipes in smoke box.
Psilobon . . . Copper stay bolts.
Psilopogon . . Roof over forward part of tender.
Psilothre . . . American open hearth tires.
Psilothris . . . Vicker's tires.
Psilothron . . Krupp open hearth tires.
Psilothrum . . Krupp crucible tires.
Psophode . . . Tender fitted with water scoop, for taking water from track tanks while running.
Psophodum . . Steel tired tender wheels, with wrought iron spoke or plate centres instead of chilled cast iron wheels.
Psoricorum . . Wheel centres.
Psoriforme . . Driving wheel centres of wrought iron.
Psorique . . . Driving wheel centres of cast steel.
Psychical . . . Wrecking frogs.

INDEX.